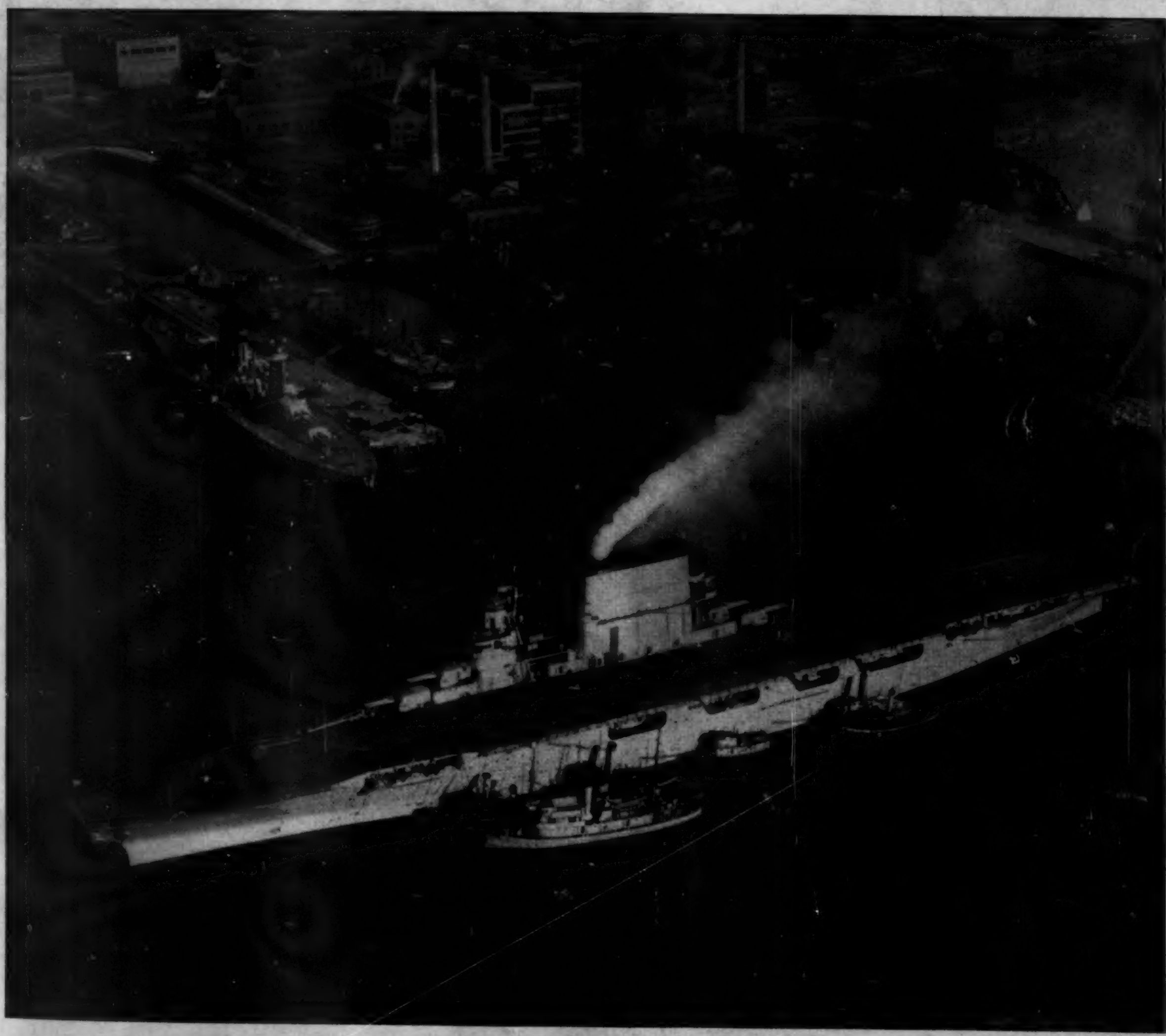
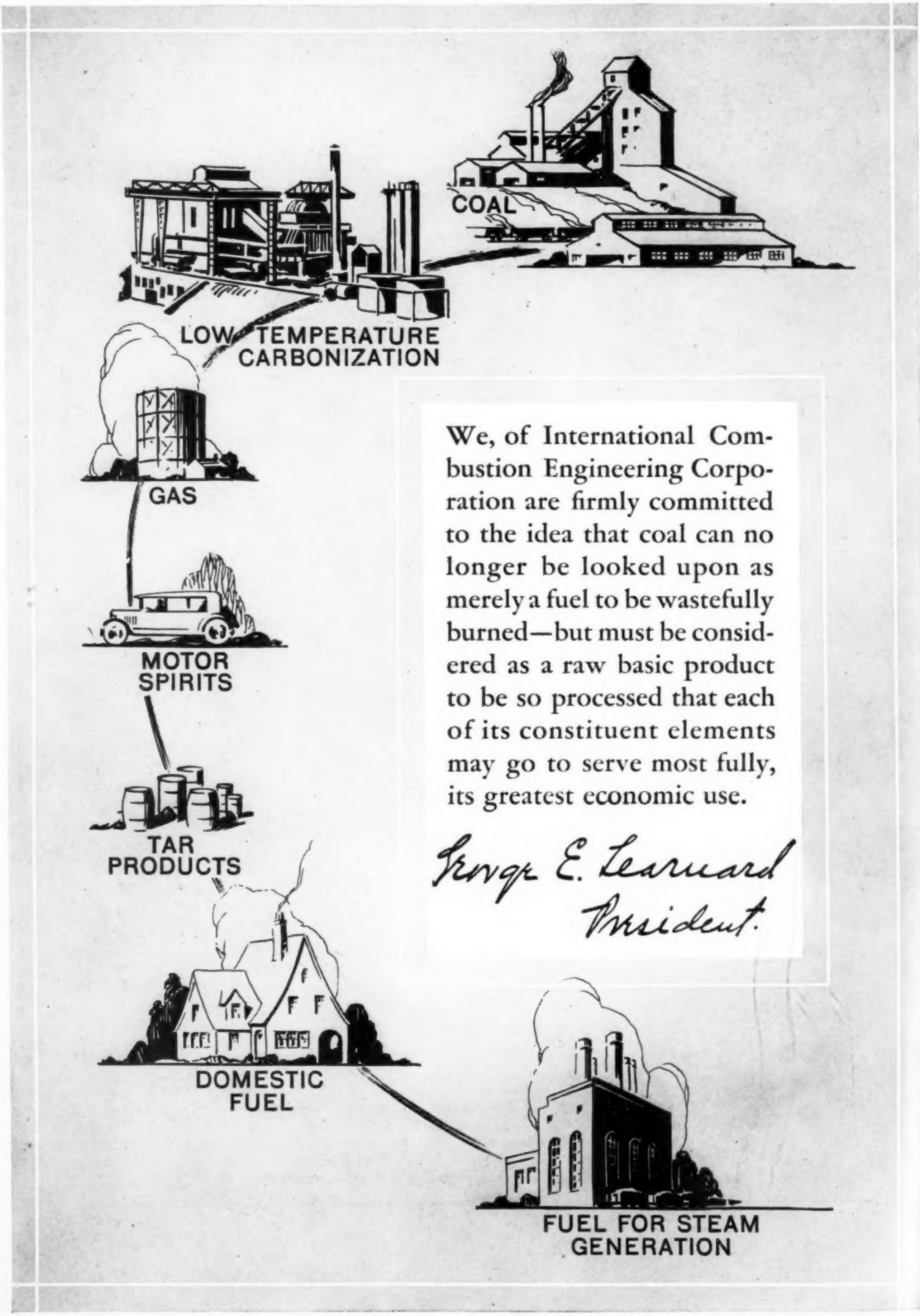
MECHANICAL ENGINEERING



THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

April 1928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We, of International Combustion Engineering Corporation are firmly committed to the idea that coal can no longer be looked upon as merely a fuel to be wastefully burned—but must be considered as a raw basic product to be so processed that each of its constituent elements may go to serve most fully, its greatest economic use.
George E. Learnard
President.

Mechanical Engineering

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DEPARTMENTAL

ADVERTISING

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C. F. Klinefelter

Glenn Frank

H. E. Howe

J. A. Moyer

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Glenn Frank, widely known publicist and educator, is president of the University of Wisconsin. He received a B.A. degree from Northwestern University in 1912 and an M.A. degree in 1921. From 1912 until 1916 he was assistant to the president of Northwestern University. In 1916 he became associated with Edward A. Filene, Boston, in research and organization. In 1919 he was appointed associate editor of the *Century Magazine*, and two years later, in 1921, he was made editor-in-chief. Dr. Frank is the author of "The Politics of Industry" and "An American Looks at His World."

C. F. Klinefelter is Federal agent for Industrial Education, Federal Board for Vocational Education, Washington, D. C. He received his A.B. degree from Ohio State University in 1912; a teacher's diploma in secondary education from the Teachers College in Cincinnati University in 1916; and a B.S. degree in industrial education from Ohio State University in 1917. In 1919 he was made a member of the supervisory staff of the State Board of Vocational Education in Ohio, and in 1920 he became an agent on the staff of the Federal Board for Vocational Education. For seven years he had charge of the development of trade and industrial education in twelve of the states of the Middle West. Last Spring he was transferred to similar work in twelve of the southern states. In connection with his work as Federal agent he has had direct experience in the conducting of foremanship courses in different industries.

Harrison E. Howe, who has been editor of *Industrial and Engineering Chemistry*, Washington, D. C., since December, 1921, has long been a leader in organizing industrial groups for research. From 1904 to 1916 he was chemist and editor for the Bausch & Lomb Optical Co., Rochester, N. Y. In 1916 he joined Arthur Little, Inc., of Cambridge, as chemical engineer, and later took charge of the commercial department of the same organization. From 1917 to 1919 he was chairman of the division of research extension of the National Research Council. During the World War he was consulting chemist for the nitrate division, Ordnance Bureau of the United States Army. He is the author of "The New Stone Age," published in 1921, and of "Profitable Science in Industry." He also edited *Chemistry in Industry*, volumes 1 and 2, 1924 and 1925, and has contributed many articles to scientific journals.

James Moyer has been director of the university extension department, Massachusetts Department of Education, since 1915. He received his B.S. degree from Lawrence Scientific School, Harvard, in 1899, and his M.A. degree from Harvard University in 1904. From 1908 to 1911 he was assistant professor of mechanical engineering at the University of Michigan. In 1911 he was appointed junior professor of mechanical engineering at the same institution. The following year he went to Pennsylvania State College as professor of mechanical engineering, in charge of the department. In 1913 he was appointed director of the Pennsylvania engineering experimental station and of the university extension department of Pennsylvania. For three years, from 1917 to 1920, he was the New England representative of the United States Department of the Interior. Mr. Moyer, who is associate editor of *Combustion*, Chicago, is also a frequent contributor to engineering journals. He has to his credit several well-known textbooks on engineering subjects.

This month's cover is an aerial photograph of the U.S.S. aircraft carrier *Saratoga*, which together with its sister ship, the *Lexington*, is described in the article in this issue on U.S. Aircraft Carriers, pages 280–285.

A.S.M.E. Spring Meeting

Pittsburgh, Pa., May 14–17, 1928

The Spring Meeting of The American Society of Mechanical Engineers gives promise of being the largest and most interesting meeting of its kind that the Society has ever held. Pittsburgh itself furnishes a splendid background for a meeting of mechanical engineers with its tremendous mechanical industries.

The May issue of MECHANICAL ENGINEERING will contain abstracts of all the papers to be presented at the meeting, together with a complete technical program. The current issues of the A.S.M.E. NEWS will carry the details of the social features of the meeting.

MECHANICAL ENGINEERING

Volume 50 April, 1928 No. 4

Power, the Background of Our Present-Day Civilization

By GLENN FRANK,[1] MADISON, WIS.

When we say "present-day civilization" in the western world, we mean machine civilization, and when we say "machine civilization," we mean a civilization made possible by power other than the power of the muscles of men and animals. But when we speak of the machine civilization of today, we speak of a machine civilization that is being created by a power different from the power that gave machine civilization its start. In other words, we are speaking of a machine civilization that has come or is coming as the result of electric power in contrast to the machine civilization that had its beginning with the introduction of steam power. And, as has been pointed out by almost every student of machine civilization, there is a radical difference between a machine civilization created by steam power and one created by electric power.

In a machine civilization created by steam power, the worker must go to the power, but in a machine civilization created by electric power, the power can be taken to the worker; and that is a revolutionary fact which means that when we say "machine civilization" in terms of 1950, we may be dealing with a machine civilization that is as different as imagination can conceive from the machine civilization which began when James Watt first harnessed the expansive power of steam to the processes of production.

It seems to me that there are technical and economic forces making for an extensive decentralization of American industry which bid fair to correct most of the evils of centralization and congestion against which the muckrakers and the mystics have been railing for a generation.

In my judgment it is only a question of time until American industry will almost completely stop the complete manufacture and assembly of all the parts of complicated machines in great industrial centers. Ultimately the various parts will be manufactured in factories located at the source of their raw materials, and for a time, of course, the great industrial centers will persist as points at which the parts manufactured elsewhere will be assembled and from which they will be shipped to local markets. But ultimately, in my judgment, the great congested industrial centers will disappear even as points of assembly, because in the end this machine civilization will inevitably ship the parts to the very doorways and thresholds of local markets for assembly.

Now, that will be, if it comes, a revolutionary industrial change, and if it does come, an equally revolutionary social change will come with it, not because of any reformers' Utopian crusade but as the result of technical progress in the field of the generation and transmission of power.

Changes in Our Machine Civilization Likely to Result from the Application of Electric Power

The topic that I want to discuss, then, is the changes in machine civilization that are likely to come as a result of the application of electric power that can be taken to the worker, if not in the place of, at least in addition to steam power, to which the worker, roughly speaking, must come.

Now, on several occasions in magazine articles and in addresses other than this I have discussed our machine civilization from two points of view: first, from the point of view of a man like Mahatma Gandhi, the social mystic of India, a man who believes that modern mankind must be emancipated from the machine; and second, from the point of view of a man like the late Walther Rathenau, who believed that mankind might be emancipated by the machine.

I want to talk a little while about these two major philosophies that are battling for the control of this machine civilization in which power is destined to play such a revolutionary part, namely, the philosophy of the social mystic, as represented by a man like Gandhi, and the philosophy of the engineer, if I may so phrase it, as represented by a man with the outlook of the late Walther Rathenau, or any of the great creative business and industrial statesmen of our time.

What the Social Mystic Thinks About Machine Civilization

I need do no more than summarize briefly what the social mystic thinks about machine civilization. He thinks very badly of it. To a man like Gandhi, for instance, machine civilization must always mean the centralization of production in great, congested cities, in which congestion breeds its ugly offspring of slums and pallid children and all that. It must mean a narcotic monotony of factory routine that will turn masters of tools into servants of machines. It must always mean a kind of mass production that will put quantity above quality. It must always mean a standardization of processes and production that will not stop with a mere standardization of processes and production, but will go on until it has ironed out the mind and manners and morals of mankind into a drab and sterile sameness.

To Gandhi, machine civilization will always mean the death, both of the inventive skill and of the independent spirit of the worker, an overspeeding that will leave mankind spiritually out of breath, and a subtle conspiracy against beauty that can end only in making ugliness and utility interchangeable terms.

[1] President, University of Wisconsin.

Address delivered at the Midwest Power Conference, Chicago, February 14 to 17, 1928.

Now, I suggest that we of the western world could dismiss all of this as simply the impractical abstraction of the mystical East, if it came alone from Mahatma Gandhi, seated at his spinning wheel, clothed in nothing but his loin cloth and his longing for a pre-machine age. But we must remember that Gandhi and his fellow-rebels against this machine age in which you are playing such a role today, are winning converts every day here in our very midst. Let me take at random a sample page from the literature written from the Gandhi point of view that is today being written by westerners themselves. I quote from a recent article:

> It is proper [says the author] to question whether the oriental at his harsh labor and his primitive home and without organized amusements or modern improvements does not derive as full a satisfaction as the American shopkeeper or factory worker. If he works hard and long, his work is not deadening; he is a craftsman and not a tender of machines; he makes something in which he can express himself; he doesn't spend his life turning one small screw a thousand times a day—always the same screw, the relation of which to the finished product he doesn't know and doesn't care to know. He has a personal relation to his work, his fellow-workers, and the product. His pace is not a thing forced by a thing of steel and driven by a power he cannot see. He chats as he works, he takes a cup of tea, stops to regard the passing excitement in the street, to greet a friend or to reprimand his children, his workshop being also his home.
>
> If he hasn't so much leisure, measured in hours, he has more leisureliness. He smiles easily, he is not smitten by the childish idea of efficiency. He can play at his work, as Americans cannot. He does not work at his play, as Americans do. When you have seen one of his cities, you haven't seen all of them. He doesn't say the same, do the same, think the same, feel the same as every other human being in the land. He hasn't been regimented and his life has not been standardized, stratified, dulled, and ironed out of every element of individuality.
>
> If [says this writer] I were a Hindu, a Turk, an Egyptian, a Chinese, or a Siberian, I should innoculate my social system against industrialism and the machine as I should against the plague.

I have ranged on the shelves of my library one entire section filled with books and monographs that have been written in this spirit against the whole machine civilization in which we are today operating, and written not by mystical orientals but by westerners themselves. The authors of these books and these monographs are western converts to the social mysticism of the East, and they are, in my judgment, what the late Walther Rathenau, distinguished head of the German General Electric Company, called "The Shepherds of Arcady."

Now, Herr Rathenau was at once a successful prophet and a successful profit maker, in other words, a seer and a good business man rolled into one, and that is a remarkable, if unusual, combination. He had little patience and less confidence to give to men who, face to face with the admitted materialism and muddling of our machine civilization, had no remedy to offer except the cowardly retreat into some Arcadian and impossible simplicity of life which is possible, at best, only to a select few of the saints and seers of any generation.

Herr Rathenau was perfectly willing to let these "Shepherds of Arcady," as he called them, run away from the challenge of machine civilization, if that was the best they could do, but as for himself he preferred to buckle down to the practical job of wresting health, happiness, security, and serenity from our machine civilization for the vast masses of men and women who cannot and will not run away from modern society to the haven of some private paradise.

I suggest that the difference between the pessimism of Gandhi and the optimism of Walther Rathenau grows very largely out of the fact that Gandhi is developing his theory for the most part in terms of the old machine civilization that was created by steam power, to which the worker had to go; whereas Walther Rathenau developed his philosophy in terms of the new machine civilization that is being created by electric power, which can be taken to the worker and can be sent hither and yon without the limitations of a machine civilization that rested upon steam power.

I am perfectly willing to grant to Gandhi and to his western converts that up to date our machine civilization has a good many things to its discredit. It has too often subjected men to a more and more terrible drudgery, a soul-killing speed of work. The savings of our machine civilization have not always been put back into it to work for the improvement of its service. Our machine civilization has sometimes been guilty of the short-sighted business policy of paying its men the least they would stand for and charging its customers the most they would bear. It has in the past built and crowded itself into hideously ugly industrial centers, and too often forgotten beauty and frowned upon quality. It has too often produced for sale rather than for use—and so on to the end of an indictment that I shall not even take the trouble to discuss, much less to contradict, save to say that these are the signs of the pioneer period through which machine civilization has had to pass. We have to remember that this machine civilization of ours, which up to date has been largely the product of steam power, is a mere fledgling among the social schemes of history, and these sins that it has been committing will in time disappear, in fact, are disappearing far more rapidly than it appears to the average individual-line onlooker, not because business men have received a sudden baptism of brotherly love but for two reasons: First, because of technical developments; and second, because it is daily becoming evident that such sins are simply bad business that do not pay profits in the long run.

Masses Have More to Hope for from Engineers, Inventors, and Industrial Statesmen than from Social Reformers

If I may put it bluntly, the masses have more to hope for from great engineers, great inventors, and industrial statesmen than from social reformers. The greatest social progress of the next fifty years will, in my judgment, come as a by-product of technical progress, and the most potent revolutionists of our time are not the Bolsheviks or the anarchists but the engineers and the inventors.

In a little German book—so far as I know, not yet translated into English—called "Apologie de Technik," by Richard Nicholas Coudenhove-Kalergi, the author says:

> The true champions of the masses are our engineers and inventors. The inventor of the automobile has benefited horses more, has saved them from more toil and suffering, than all the world's societies for the prevention of cruelty to animals. We have no galley slaves because they have been emancipated by the inventor of the marine engine. The use of fuel oil has redeemed an army of stokers from the inferno of the stokehole. The ultimate end of technical progress is to provide every man with the comforts and conveniences that are today reserved for millionaires. Therefore the inventors and the engineers are fighting want and poverty, they are not fighting wealth; they are fighting slavery, they are not fighting rulers; their object is to universalize wealth, power, leisure, beauty, happiness. The ideal of the engineers and the inventors is not to make all mankind a proletariat, but to make all mankind an aristocracy.

I quote this paragraph as a perfect expression of my central contention, namely, that technical progress and the business and industrial system born out of it may become humanity's fittest instrument for the achievement of sound social progress if these forces are handled in a statesmanlike manner, by the men whose hands are on the levers of power.

Now, I don't want to be misunderstood. If I thought that the admitted shortcomings of our machine civilization up to date were incurable, I should be inclined to throw up the sponge, buy a spinning wheel, and join the Gandhis. Or, if I thought that these shortcomings were curable but that their cure could

be effected only by reformers from outside the industrial and business system, I should be tempted to bundle my wife and boy into a seaworthy vessel and set sail for some idyllic South Sea island—if I could find one that Frederick O'Brien hadn't ruined.

And the reason I would do that is because I would have no confident hope that any reform force from outside of business and industry and the vast processes of production and distribution could ever register enough fundamental effect during my lifetime to make any noticeable difference to me.

And finally, if I thought these admitted shortcomings of our machine civilization were curable by engineers and inventors and business men themselves, but that any hope of their cure within my lifetime depended upon the epidemic sweep of a new and unique unselfishness through the business ranks, I should again consign my belief in the potentially high human values of machine civilization to the graveyard of dead dreams.

But I suggest that I am resting my hope upon a much sounder foundation. I am expressing high hopes for this machine civilization of ours, not resting those hopes on outside reformers nor on any internal reform of the human nature of business men, which I suspect hasn't materially changed since the aboriginal American Indians passed their wampum from hand to hand.

I believe that the steady advance of technical progress, plus an increasingly intelligent effort to find the soundest and most profitable forms of organization, processes of production, and methods of distribution, will, without any high-sounding declaration of unselfish social purpose, correct most of the existing evils of our machine civilization and produce a social and economic order, the normal functioning of which will in itself be the highest possible social service.

Now, let me get down to details and suggest just two or three of the ways in which I think this machine civilization which is just now emerging, that is, the machine civilization that rests on electric power in contrast to the old one that rested on steam power, is promising to correct its own shortcomings; the correction coming, I believe, as an incidental by-product of technical progress and a search for the soundest and most profitable ways of doing business.

Forces Making for an Extensive Decentralization of American Industry

Now, first, what is the outlook respecting this vexing question of the overcentralization of industry in congested areas, with all of the more or less ugly social problems that have followed in the trail of centralization? Well, it seems to me that there are technical and economic forces making for an extensive decentralization of American industry which bid fair to correct most of the evils of centralization and congestion against which the muckrakers and the mystics have been railing for a generation.

In my judgment it is only a question of time until American industry will almost completely stop the complete manufacture and assembly of all the parts of complicated machines in great industrial centers. Ultimately the various parts will be manufactured in factories located at the source of their raw materials, and for a time, of course, the great industrial centers will persist as points at which the parts manufactured elsewhere will be assembled and from which they will be shipped to local markets. But ultimately, in my judgment, the great congested industrial centers will disappear even as points of assembly, because in the end this machine civilization will inevitably ship the parts to the very doorways and thresholds of local markets for assembly.

Now, that will be, if it comes, a revolutionary industrial change, and if it does come, an equally revolutionary social change will come with it, not because of any reformers' Utopian crusade but as the result of technical progress in the field of the generation and transmission of power.

Heretofore, in the old days of steam power, we had to build our factories at the source of motive power. The production of steel centered around the coal mines of Pennsylvania; the production of flour pitched its tent near the waterfalls of Minneapolis and elsewhere, and so on. In the age of electricity, however, power can go to production. In the age of steam, centralization was almost essential and inevitable. In the age of electricity, and particularly if we emerge fully into an era of the transmission of cheap power, most of the reasons for the centralization of industry will disappear, and even the complicated processes of mass production may in the end be carried on more cheaply in a decentralized than in a centralized industry.

I shall long remember a talk I had with the late Charles P. Steinmetz in which he ventured a rather radical prophecy which he later committed to print. We were talking about the industrial and social effects that were likely to come from the application of electric power, and Steinmetz said this to me:

"Sooner or later high-potential lines"—this was several years ago—"from central stations will be able to transmit sufficient power to turn all the wheels of industry. Electricity ultimately will be used so generally that the cost will likely be apportioned on the basis of a tax like our water tax today. The charge will probably be so much a plug, as we are now charged so much a faucet. Electricity will some day be so cheap that it will not pay to have meters installed, readings taken, and a system of accounts kept."

Now Steinmetz was assuming that the social control of electric power would keep pace with technical progress in the field of power. Of course, we may present a resistance to what some might think the socialistic undercurrent in the Steinmetz assumption, and our resistance may be stubborn enough to upset a large part of his prophecy, but even if we never subject electric power to the same sort of social control we now exert over water supply in our cities, the fact remains that we are on the eve of an era of superpower that will make it possible to put our factories at the source of raw materials rather than at the source of motive power alone, and that ultimately, I suggest, is bound to mean the decentralization of American industry; and if through the developments in the field of superpower American industry is ultimately decentralized, then obviously most of the ugly social problems that have followed in the wake of industrial centralization will automatically disappear as industry moves from centralization to decentralization.

Now, the thing that many critics of our present-day machine civilization have overlooked is this: They have assumed that we couldn't have mass production without great centralization of industry, and they have said that we couldn't remedy the evils of centralization without giving up mass production; and, knowing that there was no likelihood whatever that we would ever give up mass production, they have said that the evils of centralization in machine industry are therefore incurable.

But now, thanks to technical developments in the field of electric power, the outlook is, as I have said, that we may find it possible in the future to carry on even mass production more profitably in a decentralized than in a centralized industry.

Now, of course, this is going to throw us into all sorts of complicated situations. This coming decentralization of industry as the inevitable result of power developments is going to reopen the whole question of freight rates—and here is a problem that challenges both our business genius and our social statesmanship to sustained study and planning, so that we shall not be caught napping on such collateral issues as freight rates when this decentralization comes as a result of the work you men are doing

in the field of power. If we do not, as a nation, adequately anticipate the freight-rate problem that will be involved, we shall have to suffer a long and costly social and economic struggle that a little foresight on our part now can prevent.

Side Effects of Decentralization of Industry Brought About by Developments of Power

Of course, there will be all sorts of side effects to this decentralization of American industry brought about by the developments of power. One of them, I think, is worthy of mention here, because it is a development that may go very far toward meeting the difficulties that today vex the American farmer.

The agricultural regions of America are the source of many industrial raw materials, and every year they become the source of more, because every year the industrial chemist is finding new industrial uses for the main products and the waste products of American farms. Corn, wheat, rye, flax, barley, cotton, wood, sawdust, cornstalks, corncobs, straw, cottonseed, husks, whey, and many other main products and waste products of the farm are already being transformed by the industrial chemist into movie films, printer's ink, wallboard, dynamite, glue, floor covering, radio parts, substitutes for ivory, silk, leather, linen, marble, and an endless list of manufactured articles. Now, if the future development of power and its transmission makes possible the locating of factories in the agricultural regions that are producing their raw materials, then there opens up the possibility of a correlation of agricultural and industrial products in which there are fascinating possibilities.

Now, as some one has said, farming, except in such fields as dairying and others that have been organized on a business or industrial basis, is not in most instances a full-time job. Industry, however, is. Now, the phrase "Farm and Factory Must Prosper Together" has become a slogan. If technical developments in the field of power production and power transmission make it possible to put small factories in agricultural regions, then we may get a new slogan, "Farm and Factory Must Work Together," and we may correlate agricultural and industrial production. That is to say, if small factories can ultimately be planted throughout the agricultural regions of America, absorbing and utilizing as raw materials many of the main products and certainly all of the waste products of the American farm, then we may get a double outlet for human energy that will absorb in the factory the present seasonal idleness of farm labor to an extent that will put a sound economic foundation under agricultural regions without the succor of governmental subsidy.

There are a thousand and one difficulties in the way of any such development, but I know a great many far-sighted men who think it promising enough to justify considerable thought and investigation just now.

If now Mahatma Gandhi had been listening to my argument up to this point, he might say, "Well, suppose superpower does succeed in pushing the factory system out of the cities on to the countryside. It will only spread the blight of standardization and factory routine over areas that until now have been saved from it."

Now that raises the whole question of how much is reality and how much is "hokum" in the discussion of standardization and routine in production that we are hearing all the time. I am not sure that standardization of production processes, with all of the routine that it implies, is the unmixed evil that its critics assert. I realize the deadening effect that the monotonous repetition of a single specialized movement has upon a worker. It is true, by and large, that the man who makes one-forty-second of a watch is likely to become sooner or later one-forty-second of a watchmaker, for standardized machine production just does not make for creative craftsmanship in the worker. But I remind myself constantly that it isn't every worker in the world who is a suppressed artist champing at the bit to create. The brutal truth is that there is a vast amount of mediocrity in the human breed, and standardized machine production has given mediocrity its first chance in human history to make even a better living than the ancient artist craftsmen made. The mediocre worker, thanks to machine production, today has a cottage and a car; in a handicraft world he would be living in a hovel and walking. And in the machine civilization of the next fifty years the machine civilization that electric power is creating, I am not so sure that the creative craftsman himself will be so terribly bad off, because the further development of mass production which is bound to come will give to that creative craftsman two inestimable boons—leisure and means.

I say that because the outstanding fact of mass production and mass distribution is that its effective administration enables the manufacturer to do four apparently contradictory things at one and the same time. It enables him not only to raise wages, lower prices, shorten hours, but also to increase his total profits at one and the same time. And some of the most brilliant examples of business success in America rest upon the fact that these four things have been done in the business at one and the same time.

Higher Wages, Shorter Hours, and Lower Prices Made Possible by Mass Production and Distribution

Now, the first three of these, higher wages, shorter hours, and lower prices, mean leisure and means for the workman, the creative workman, whose spirit is, frankly, bigger than the set task he does in the factory. In my judgment there is no reason why, with the short hours and high wages that a more and more intensified standardized mass production will make possible, the more creative-minded workman may not become just as all-around a man as his craftsman predecessor in the Middle Ages. If he doesn't utilize the new leisure and the new means made possible by machine civilization in order to make himself an all-around man, he will in the long run have only himself to blame.

Now, of course, there are men like Gilbert Chesterton, whose body is in the twentieth century and whose mind—I mean his spirit, his affections, his ideals—is in the thirteenth. There are men like him who are always holding up the peasants and craftsmen of the Middle Ages as so much better-balanced men than the tenders of machines who work in the factories of this age of power. Listen to Mr. Chesterton. He says:

> The peasant almost always runs two or three side-shows and lives on a variety of crafts and expedients. The village shopkeeper will shave travelers, stuff weazels, and grow cabbages and do a dozen such things, keeping a sort of balance in his life.
>
> The method isn't perfect, but it is more intelligent than turning him into a machine in order to find out whether he has a soul above machinery.

Well, if the modern factory worker were doomed to a life of long hours and low pay he might indeed long for the small independence of the peasant and the handicraftsman of earlier and simpler centuries. But I submit that it is an open question whether in the long run he may not be better off spending a reasonably short day in the admittedly uninspiring repetitive labor of a modern factory, but with leisure and means at the end of the day.

Now, I don't want to be misunderstood. The happiest man in the world is the man whose work is at one and the same time a means of self-support and a means of self-expression. But we might just as well be practical about all this; for good or for ill we are committed to machine production. We are not going

to take out our telephones and beat a hasty retreat to the Middle Ages. Even the most creative craftsman among us must face the necessity of living out the rest of his life in the midst of the processes of a machine civilization.

And so I say that, whatever our perfect theories may be, it is gratifying to know that our machine civilization in the normal perfection of its processes is making for shorter hours and higher pay, thus staking out larger and larger areas of leisure in the lives of the rank and file of workers, larger areas of leisure in which they may, if they will, laugh and love and adventure among things of the mind and of the spirit.

Standardization Not an Unmixed Evil

Now, so much for the results of standardization on the individual. "But," you say, "what about the effect of standardization that this machine civilization is producing on civilization as a whole?"

Well, now, I have broken my lance a good many times in fights against the standardization of the American mind, but here again I think a vast amount of unadulterated silliness has been spent upon the discussion of standardization, the standardization of our minds as a by-product of the standardization of our machines, for this reason. A certain amount of standardization is necessary to the living of effective lives. If we didn't standardize and render more or less automatic the processes of shaving, dressing, and eating, for instance, we should have to spend all of our time in the bathroom and the dining room. I know men who do most of their really creative business and professional planning for the whole day while they are bathing and shaving in the bathroom. Why? Because these processes of bathing and shaving and dressing have become so standardized and so automatic that their intellectual energies are free for much more important things.

Now I suggest that the same thing may be true of a civilization and that these vast processes of the production of necessities may become so standardized and so automatic that the major energies of this whole civilization can be free for bigger and for more important things than just food and clothing and shelter.

To take only one other aspect: The critics of this machine civilization that you are doing so much to alter and to intensify and to make more complicated, are constantly saying that the day of the smaller producer and the small property holder is over. Now, if this were true, frankly, I should regret it. I think there is something about the psychology of small property and small-scale production that is healthy; and, obviously, in the old machine civilization that rested entirely on steam power the small producer was doomed, because production became essentially an enormous factory process.

Development of Cheap Power Transmission Promises a Revival of Small-Scale Industries

But now that a new machine civilization is emerging, resting upon electric power that can go to the worker, I am not at all sure that the day of the small property holder and even the small-scale producer is over; I am not at all sure that you men who are working in the field of power may not be making possible the return of the small-scale producer. I don't mean as the dominant factor or as serious competitors with mass production and mass distribution, but the possibility of small-scale production and the return of the small-scale producer as part of a large mass-production procedure that may be worked out in the future.

To illustrate: The development of cheap power transmission may make feasible more and more machines manageable by one man or a dozen men who will do virtually all of the manufacturing of finished products in the fields of simpler articles, such as flour, clothing, shoes, and the like. I heard some time ago, from an engineer who had looked it over, of a man who had perfected a one-man flouring mill about the size of an ordinary carpet sweeper or vacuum cleaner. Now, when you stop to think of it, the modern printing press prints, folds, piles, and counts vast editions of a newspaper while a mere handful of men watch it to see that it functions properly. As far as the mechanical processes of production are concerned, the manufacture, even of a great metropolitan newspaper, is essentially small-scale production, even though the edition is staggeringly large, because it is the product of machinery that a few men can manipulate. So I suggest that technical progress and invention are likely to give us machines that will make possible a genuine revival of small-scale industries, and the revival of those small-scale industries will not be inconsistent with the further and further development of mass production and mass distribution.

I leave it to you to think out all of the social implications that may be involved in the prophecy that I have just made.

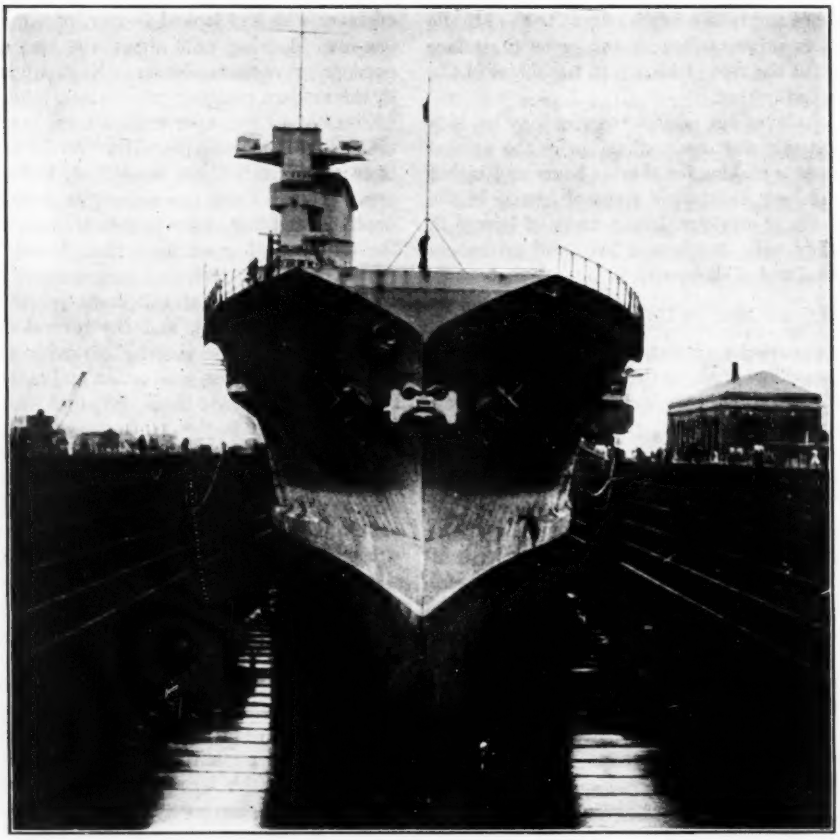
I should like to talk about what this machine civilization that is being created is likely to do to beauty, what it is likely to do to a dozen other fundamental factors in civilization. But I must content myself with the suggestion that all of these very desirable social effects will not be produced simply by the creation, the generation of, power and the invention of devices for its transmission. If you are looking at the power problem purely as engineers concerned with generating power and making possible its transmission across the nation, you are at any rate leaving out some of the most important conditioning factors in your problem, because, after all, the extent to which power will be used in factories, on farms, and in homes will depend in large measure upon the cost of the technical devices that the manufacturer, the farmer, and the home owner must buy and install before he can use this power that you are generating.

That is, the men who manufacture and sell power devices for factories, electric irons, washing machines, ironing machines, vacuum cleaners, and the various electrically driven farm devices might either slow down or speed up the use of power in this country for the next fifty years, and in slowing down or speeding up the use of power they could slow down or speed up these highly desirable social by-products about which I have been talking.

Power Problem Not Merely One of Generation and Transmission

In other words, I am trying to suggest that you cannot really attack the problem of power merely as a problem of generation and transmission. Before you know it, you will be face to face with the problem of prices, which will lead into the whole problem of the policies and procedures of the American business system, which means that in addition to the technical inventor, the ranks of American business and industry must produce business statesmen also, who can see all the parts of this problem in their relations.

And now I conclude with one suggestion, and that is that if the power resources of the United States during the next twenty-five years become mere pawns in a game of financial manipulation, we shall miss many if not most of the rich social benefits that electric power can bring to American civilization, and we shall probably find ourselves in the midst of a social revolt against the perversion of this great social asset to purely financial ends. The generation, the sale, and the use of electric power represent a factor that, wisely administered, can remake our machine civilization, redeeming it from the sins that have shamed it in the past; but we shall not achieve this wise administration of this new power unless the voice of the engineer and of the industrial statesman outweighs the voice of the financier alone in the development and control of power.



Wide World Photos

FIG. 1 THE "LEXINGTON" IN DRY DOCK

U.S. Aircraft Carriers

The Value of Aircraft in Naval Warfare and the Necessity for Floating Bases—The U.S.S. "Saratoga" and "Lexington," Their Huge Steam-Electric Power Plants and Controls—Aeronautical Features of Aircraft Carriers

AN AIRCRAFT carrier is as much an expression of utmost modernity as is the radio, television, or the vocally controlled operator; and it is only the development of aircraft and the recognition of its place in naval tactics that justify the huge expenditure involved in the construction of this kind of ship.

There are two schools of thought in modern naval circles with respect to the place of aircraft in naval tactics. One school (most prominently represented in this country by the former chief of the Army air service, General William Mitchell) would make aircraft the paramount means of naval warfare. The tests with certain former German battleships off the Virginia Capes where these big vessels were sunk by bombs dropped from aircraft, and the recent tests off Panama, where to everyone's surprise comparatively small bombs were sufficient to sink fairly large armored vessels, would lead one to believe that the days of the surface vessel are numbered, and that no vessel can live if attacked by sufficiently well-equipped aircraft operating in adequate numbers.

This view, however, is very far from being accepted as true by many leading navy men either of this country or abroad. Their claim is that, while the day may come when any surface vessel, no matter how well protected, may be blown out of the water by aircraft, that day has not yet arrived, and may not for quite some time. They claim that at least at present it is only by the use of such surface vessels as battleships and cruisers that certain strategic problems of the Navy can be accomplished. The next contention of the defenders of present navies is that the development of anti-aircraft guns, and certain improvements in the construction of modern craft have been such as to make attack from the air less dangerous in actuality and under real war conditions than it would appear to be from tests carried out when the sun was shining, at a short distance from shore, and when the aircraft were permitted to attack while their targets could not defend themselves.

VALUE OF AIRCRAFT IN NAVAL WARFARE

No matter, however, what view may be held as to the offensive power of aircraft in naval warfare, two things may be said to be thoroughly recognized by the naval administrations of the principal countries. In the first place, there is no longer any doubt that whether or not the offensive power of the aircraft

is as great as its opponents would want one to believe, there is such a power, and to put it colloquially, the aircraft hornet has a really formidable sting. There is no doubt that today a navy deprived of protection from the air would be greatly inferior to one possessing such protection. In the next place, there is a universal recognition of the enormous value of aircraft as a means of collecting information as to the movements and position of the enemy's fleet. In certain recent maneuvers such as those of the U.S. fleet near Hawaii and of the British Navy in the North Sea, the ability to see what is going on behind the usual destroyers' screen of the enemy has brought about changes in methods of operation which have been truly startling to the older men. To cite two incidents from the World War, undoubtedly neither the escape of the German crusiers *Goeben* and *Breslau* nor the doubtful conclusion of the battle of Jutland would have been possible had the British Navy possessed aircraft that would have kept it informed of the enemy's movements.

This recognition of the value of aircraft in naval warfare brought with it the problem of how best to make use of such craft. Even before the World War attempts had been made to secure some sort of cooperation between aircraft and surface vessels, and tests had been carried out on the launching of airplanes from battleships either by means of rope runways or, as in the American Navy, by catapults. This experimenting was, however, done in a haphazard manner with the least possible expenditure of money and as an obvious makeshift. It was only after the World War that a really earnest effort was made to produce a vessel so designed as to be capable of acting as a landing and starting place for aircraft, and at least to some extent as a mother ship for "the navy that flies."

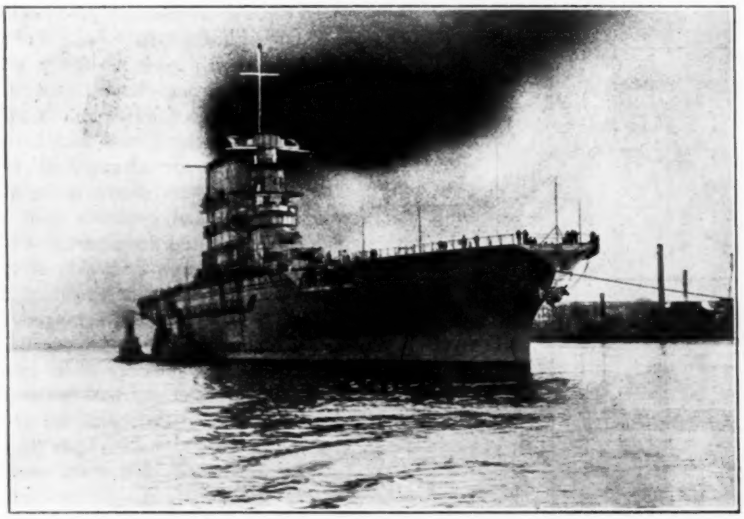


FIG. 2 THE "SARATOGA"

The British went even so far as to redesign their latest battleships so as to make them adaptable for the efficient handling of aircraft. The final evolution of this idea is the modern aircraft carrier, such as the *Saratoga* and *Lexington* in the United States Navy, frankly designed with the exclusive purpose of acting as a floating base for aircraft.

THE HUGE POWER PLANT REQUIRED BY THE MODERN AIRCRAFT CARRIER

The engineering of such a vessel is an obviously difficult proposition. Aircraft are very bulky. An airplane with its big wings and long fuselage occupies an enormous amount of space, and an airplane carrier, to make it worth having, must be capable of providing facilities for a considerable number of planes. From its general appearance one would say that the *Lexington*, for example, ought to be able to carry between 70 and 80 planes. This means a ship of very considerable dimensions, say, 900 ft. long or more. The second requirement which has to be specified in the design of an aircraft carrier is high speed. Such a carrier must not only be capable of keeping pace with the modern cruiser flotilla, which means anywhere from 25 to 30 knots top speed, but must be actually capable of either advancing ahead of it or catching up with it from behind. This means a speed of some 35 knots. In other words, an aircraft carrier is a vessel of battle-cruiser size and destroyer speed, a combination such as has never been attempted before in any navy and one which involves the necessity of solving the most difficult problem of design that can be encountered in a vessel. To realize this difficulty it suffices to remember that the power necessary to propel a vessel at a given speed varies substantially as the cube of the speed. When the speed is as high as 35 knots the power necessary to put into the propelling machinery runs up tremendously. In the case of the *Lexington*, it is said to be of the order of 180,000 kilowatts. To the modern mechanical engineer this does not seem so excessive, considering that there are actually under construction today turbo-generators of even greater capacity.

Among other things, the decision of the Navy to install turbo-generators in units of 45,000 kw. on the *Lexington* bears testimony to the confidence of the engineering profession in the reliability of these huge machines. Working conditions on an aircraft carrier are obviously such as to require machinery that will not need frequent repairs. The vessel may operate in distant waters, around Hawaii, the Philippines, China, the Panama Canal, or possibly on the eastern side of the Atlantic. During war time, if any, it will see hard service. Because of the limitations of tonnage of aircraft carriers under the terms of the Washington Conference, only a very few vessels of this kind can be built, and none can be spared if the day ever comes when they will all be called upon to perform the ultimate task for which they were designed. Machinery of the maximum ruggedness and least liability to trouble necessitating major repairs must be installed, and the selection of generators in units of 45,000 kw. capacity gives the answer.

When it is considered, however, that 180,000 kilowatts of generating machinery with boilers, condensers, and auxiliaries has to be carried within a hull traveling through the water at express-train speed, and that room must be additionally provided for electric generators of that capacity as well as electric motors, the difficulty and magnitude of the problem become fairly apparent. Another way to realize what the 180,000 kilowatts of steam and electric machinery on the *Lexington* may mean, is to remember that several countries in eastern Europe which have diplomatic representatives in Washington and full membership in the League of Nations, do not use as much electric energy for all lighting, heating, and power purposes within their confines.

THE "LEXINGTON'S" POWER PLANT AND ITS CONTROLS

The power plant on the *Lexington*, which differs only in minor respects from that of the *Saratoga*, begins with 16 oil-fired boilers each of about 14,500 sq. ft. heating surface. Roughly, 1 kilo-

watt is generated per square foot of heating surface. These boilers are of the Yarrow express type and are provided with the usual accessories. Of particular interest among the latter is the Anthony feedwater regulator, made by the Aster Engineering Company in England, which is quite extensively used in the British navy and merchant marine, but is comparatively little known in the United States. It has also been installed on the battleship *Maryland*.

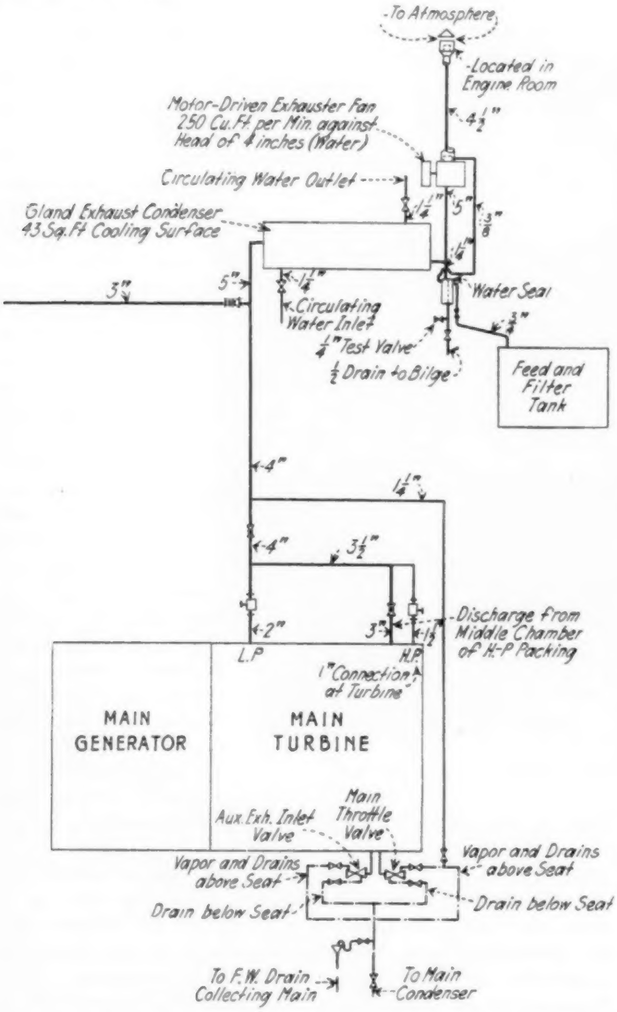


Fig. 3 Piping for Conveying Gland Leakage to a Special Condenser

This regulator, which for official reasons cannot be illustrated here, consists of a valve carrying the full boiler pressure, and held down to its seat by this pressure on the other side of a little space in a balanced piston. Between the valve and the piston is a sleeve through which there is a small hole. Water is admitted from the boiler to the space surrounding the sleeve, passes through the hole in the latter, and fills a space below the piston which communicates by a tube with an outlet. As long as this outlet is open the valve stays closed and the system is in balance. However, when the outlet is closed the water fills the whole space under the piston, whereupon the boiler pressure is brought to bear upon it; the piston becomes inoperative and is forced upward, which in its turn causes the valve to lift and admit water to the boiler. The other part of the regulator consists of a control box carrying a float, and it is the movement of this float and rod attached to it which opens and closes the outlet below the balanced piston. One of the advantages claimed for this valve is that only a very small part of the boiler feedwater has to pass through it under normal conditions.

Each boiler furnace is equipped with eight B. & W. oil burners which are quite impressive in their size. The operation of these burners is regulated from the control room and the general system of control is as follows.

Let us assume that for a given cruising speed six boilers are in operation. Five of them will then be set for a certain output and, say, five of the burners in each will be lighted. All the minor variations in load are then taken care of by increasing or decreasing the number of operative burners in the sixth or control boiler, and, of course, when greater variations of load have to be handled than the control boiler can manage, additional burners in the five base-load boilers are either lighted or extinguished, the number of burners in operation being the same at all times in all the base-load boilers.

The superheaters, in the shape of an inverted V, are set within the nest of boiler tubes itself.

The main turbines have 13 stages and are rated at 35,200 kw. when running at 1755 r.p.m., 265 lb. gage steam pressure, 50 deg. fahr. superheat, and 28.5 in. vacuum.

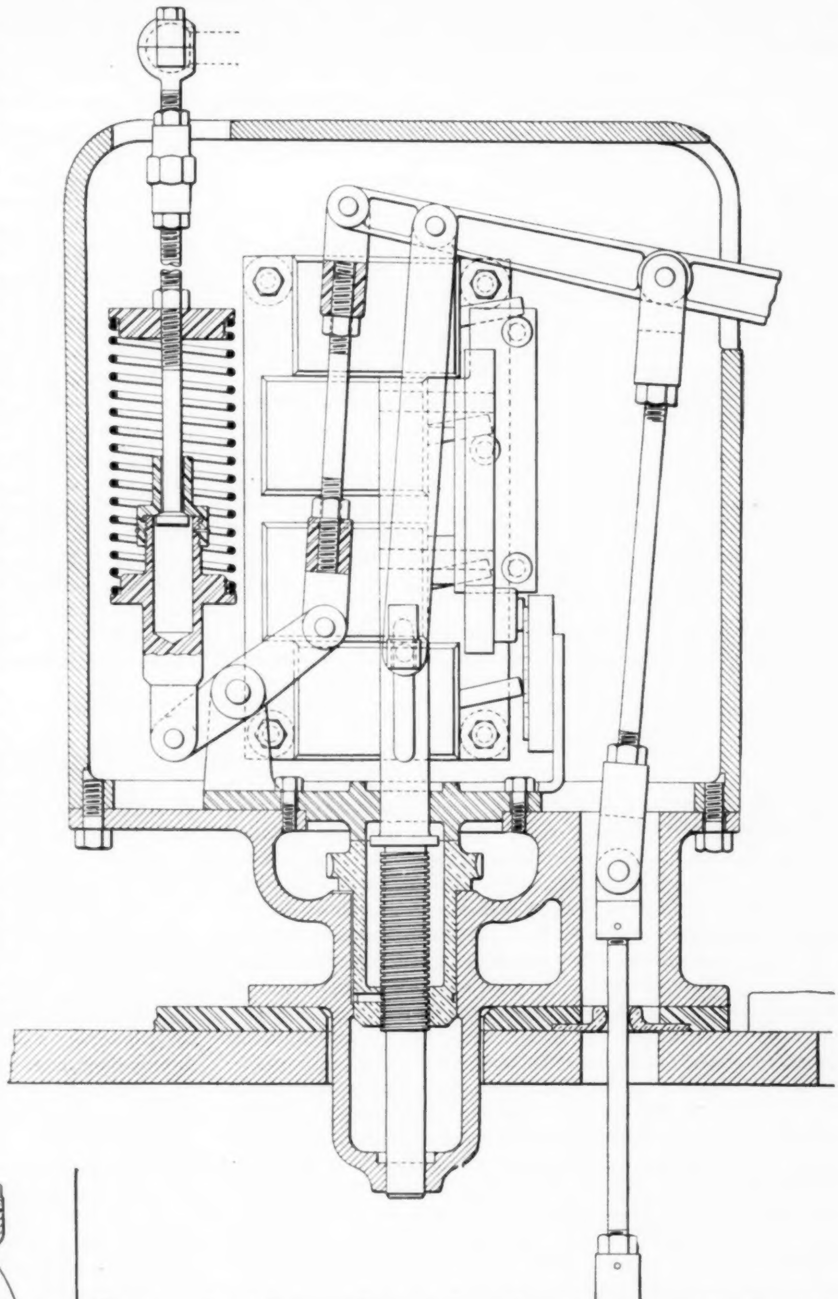
The turbines are arranged to take steam from a common 20-in. high-pressure steam main which loops both machinery compartments and connects to a battery of 16 boilers. The boilers are located in separate adjacent compartments, eight being distributed on each side of the machinery spaces. Each main turbine has its independent condenser system, including two surface condensers arranged for upward exhaust. The condenser auxiliaries are steam driven, exhausting at a back pressure of approximately 10 lb. gage per sq. in. into a common low-pressure exhaust for boiler-feed heating. Each main generator is provided with an independent water-circulating system for supply to the generator air coolers. This system consists in general of a small centrifugal pump built integral with the main circulating pump and connected through suitable manifolds with the banks of air-cooler sections. Between the cooler sections and the overboard discharge a hydraulic air-ejector system is connected to maintain a partial vacuum in the water passages of the air coolers for the purpose of preventing possible leakage of sea water into the air passages of the generator ventilating system.

The turbines in general are of the conventional design with one exception, and that is (Fig. 3) that the gland steam leakage is not allowed to escape into the engine room but is conveyed by a pipe to a small auxiliary condenser. This is not done to save the steam, which is negligible in amount, but to make the engine room pleasanter for its occupants, something which may prove to be of very considerable importance when the ship is in southern waters.

The generators connected with the turbines work at 5000 volts and the current is conveyed to the motors, of which there are two, of rated capacity of 22,500 kw., on each shaft. The motors are placed one back of the other so that the motor shafts are in line with the propeller shaft. They are rigidly connected with each other, the rigid connection between the motors having been used principally because there is no flexible joint made for the amount of power here involved. The motors are enclosed and the circulation created by suction fans driven by 125-hp. motors. The only feature of special interest in this connection, apart from the size of the installation, is the fact that the fan motors are working on 5000 volts, which is rather unusual for such small motors. The reason why this voltage was selected was the desire to be absolutely certain that the fan motor would start as soon as the main motors had started.

The best way to secure this simultaneous operation was by putting them on the same line, which does away with intermediary devices such as step-down transformers or attaching the fan motors to supply lines independent of the main motors. Thus far no trouble whatsoever has developed with these motors.

The main turbine control is effected by means of the usual governors, but in addition to these a steam limit control is installed. This steam limit control is peculiarly a marine-turbine device and would be entirely superfluous in a land central station. When a ship is executing a turn the conditions of steam supply to the main steam turbines are such that if no protection in this respect were provided, there would be a danger of the main governor's overloading the turbine with steam. To prevent this the steam limit control (Fig. 4) is installed. This consists of a spring-controlled rod shown on the left-hand side connected by a linkage to a valve on the right-hand side, and it will be noticed that in this linkage, at the bottom of the right-hand side, there is a slot in which an adjustable pin is located. The governor works on the rod against this spring. If there were no pin in the slot in the linkage on the right-hand side, the rise of the steam-admission valve (located as stated on the right-hand side) would be proportionate to the governor motion or degree of compression of the spring on the left-hand side. However, by properly adjusting the pin, the amount which the linkage on the right-hand side can move will be restricted, so that even if the governor tends to open the steam-admission valve wide, the pin



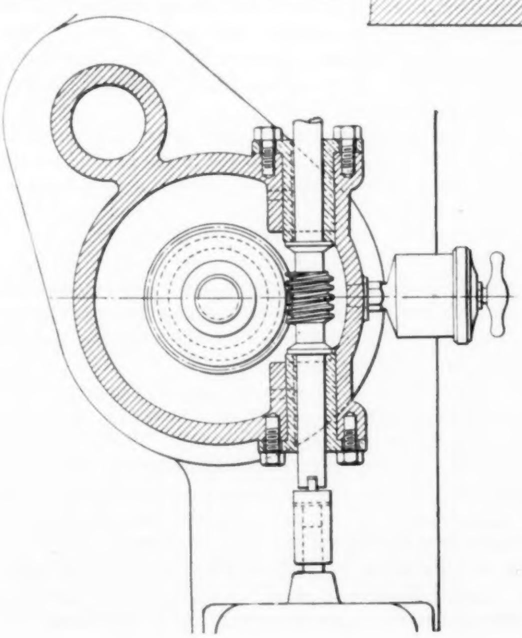


Fig. 4 Sections Through Steam Limit Control for Main Turbines

will prevent it from so doing, except to the extent permitted by the setting of the pin.

A small electric motor ($^1/_4$ hp.) operates the worm gear shown in the drawing and thus locates the pin restricting the steam admission to the desired extent. The way this device operates is somewhat as follows: When the ship telegraph shows a turn or other conditions arise which may cause an overload of the main turbines by steam, the operator in the control room actuates the above-mentioned motor in such a way as to produce the proper movement of the pin and thereby restricts the maximum amount of steam that may be admitted to the turbine, without, however, interfering with the operation of the main turbine governor.

The main motors, of which as has been said before there are

two on each propeller shaft, have a squirrel-cage winding for starting and are phase wound for regular operation. Their speed may vary from a maximum of 217 r.p.m., which corresponds to the vessel's speed of 35 knots under standard conditions, down to a very low speed, and it has been stated that as low as 60 r.p.m. has been used without trouble. This wide range

Fig. 5 Distinguishing Insignia for Upper Surface of Upper Wing of U. S. Navy Airplanes

of speeds, of course, affords the vessel an excellent maneuvering ability.

The stator winding of each motor is arranged for low-speed connection of 44 poles and a high-speed connection of 22 poles.

To operate the auxiliaries, six turbo-generators are provided delivering direct current at 240 volts. The capacity of each of these auxiliary turbo-generators is rated at 750 kw.

Aeronautical Equipment of the "Lexington"

The aeronautical equipment of the ship consists of a large space between decks used for the storage and, to a certain extent, assembly of airplanes, with elevators to the upper deck which is the landing and take-off platform. In addition to this certain repair facilities are provided. The upper deck is of the free-deck type used in some of the recent British battleships, in addition to the conventional aircraft carriers. The noticeable feature of this deck is that the funnels and gun turret are all located at one side of the deck, leaving the rest of the space free for aircraft purposes. The big guns are located in this turret, while the small high-angle-fire guns, intended primarily for protection against enemy aircraft, are placed on shelves on the side of the vessel and just below the main deck, thus leaving no blind spots, no matter from which side enemy aircraft might approach the carrier, and yet being out of the way of planes landing upon or starting from the top deck.

The United States is not the only country that is building fast vessels, of course. Recent official trials of the new French 10,000-ton cruiser *Duquesne* have shown a speed of 32 knots, and it is expected that 35 knots will be obtained when the machines have worn down a little and are ready to be pushed. This cruiser, which may be considered as representative of modern practice, has a length of 191 m. (626 ft.) or about two-thirds the length of the *Lexington*, is armed with eight guns of 203 mm. caliber in addition to eight 75-mm. guns and eight anti-aircraft guns, and has a catapult for launching two airplanes. It was therefore very important that the United States aircraft carriers should develop at least an equal speed.

A New Steam Generator Installation

At the power plant of the A. E. Staley Manufacturing Co., of Decatur, Ill., a new steam generator has been installed of the tube-furnace type. The thin-tube-type water-cooled furnace is provided at the bottom with a water screen and at the rear with a convection heating surface. A superheater is installed at the lower rear part of the unit in the gas path between the water screen and the convection heating surface. This superheater having a surface of 1570 sq. ft. is installed so that the inlet and outlet headers are outside of the furnace proper. No economizer is used, but an air preheater of the plate type is installed above and behind the unit.

The unit is fired from all four corners of the furnace, the burners being located so that their combined action produces a turbulent spiral motion of the fuel and gases downward through the furnace. The burners are round cast-iron nozzles 6 in. in diameter. There are eight burners, four for each pulverizer mill, arranged in two planes of four, or one in each corner to a plane. The planes are 2 ft. 6 in. apart. Air for combustion is taken, or rather is forced (due to the action of the forced-draft fan delivering cold air to the preheater), from the air preheater into a rectangular duct installed around the sides of the furnace. From this duct the heated air is delivered to the burners and to the pulverizer mills where it aids in driving the moisture from the coal to assist in pulverization.

The control of this unit is of exceptional interest. Except for the initial lighting of the burners the entire operation is controlled by push buttons from the main control board. This board is located in front of the generator on the operating floor. It has mounted on it a steam flowmeter, a multi-point draft indicator, a recording steam pressure and temperature gage, a recording pyrometer, a recording and indicating CO_2 meter, as well as all the control push buttons. The drum controllers for the forced- and induced-draft fans are mounted directly in front of this panel.

All the motors driving the various fans and mills are fitted with thermal overload relays and the mill motors, exhaust fan motors, and the forced- and induced-draft motors are in addition fitted with definite time-limit relays. The control is entirely foolproof, the relays being so set and so interlocked as to prevent any of the motors being stopped or started except in their proper order and at the proper time with respect to each other.

No part of the system can be started unless the forced- and induced-draft motors are operating. Once there are placed in operation by means of the push button on the control panel, the other motors driving the mills and exhausters can be started in proper sequence. When shutting down, the mill motors stop first, followed by the exhaust fans 30 sec. later; finally, the forced- and induced-draft motors stop 2 min. after the stopping of the exhausters. This is done to clear the furnace of all coal and combustible gases.

An interesting feature of the new generator is the amount of space which it occupies as considered in the light of its capacity. The generator occupies the same column spacing and area as provided for either of the present boilers 13 and 14, and develops 5000 hp. as compared with 2000 hp. of maximum capacity for the boilers 13 and 14. Furthermore, because of the entire abesnce of brickwork in the furnace the generator can be put on load from cold in from 10 to 15 min. and if repairs are necessary the generator is cool enough 30 min. after the coal is shut off to enable a man to enter the furnace.

The arrangement of the turbine room is of interest as it shows what can be obtained in industrial-plant design by the application of practices in central-station work. The article gives also a description of some very interesting electrical features of the installation. (*Power Plant Engineering*, vol. 32, no. 4, Feb. 15, 1928, pp. 242–248, 10 figs., *d*. See also the description of the Morgan & Wright plant of the U. S. Rubber Co., Detroit, Mich., in the same journal for Feb. 1, 1928, pp. 171–173, where the same type of furnace is used. A table is given showing daily performance of the steam generator for ten typical days.)

The Machinery Industry of the World[1]

A Digest of Memoranda Submitted to the International Economic Conference Held Under the Auspices of the League of Nations, Geneva, May, 1927

DATA presented to the International Economic Conference held in Geneva, May, 1927, include what is understood to be the first analysis of the machinery industry of the world that has ever been published. Most of the following material was developed by Dr. Lange, of the Verein Deutscher Maschinenbau-Anstalten, who endeavored to establish the capacity of the world's engineering industry, and also the actual output for both the pre-war and post-war periods. Using the years 1913 and 1925, he developed Table 1. This tabulation assumes that the industry in 1913 was operating at 100 per cent capacity in all countries. Obviously, this can scarcely be true, but it would introduce a great many difficulties to try to reduce the figures to a more accurate basis and it is felt that no serious deception is involved in presenting the material in its present form.

TABLE 1 OUTPUT AND OUTPUT CAPACITY OF THE WORLD'S ENGINEERING INDUSTRY

	1913		1925						
	Output		At pre-war prices				Degree of activity,	At current prices	
			Output		Output capacity			Output	Output capacity
	Millions of dollars	Per cent	Millions of dollars	Per cent	Millions of dollars	Per cent	Per cent	Millions of dollars	
United States..	1,612	50.0	2,015	57.6	2,697	57.1	74.5	3,022	4,046
Great Britain..	381	11.8	478	13.6	549	11.6	87.1	716	823
Germany......	666	20.6	460	13.1	799	16.9	57.6	690	1,199
Other countries.	567	17.6	547	15.7	681	14.4	80.3	822	1,019
Total......	3,226	100.0	3,500	100.0	4,726	100.0	74.0	5,250	7,087

Americans will be particularly gratified in noting that the United States is credited with producing 50 per cent of the world's machinery in 1913 and 57.6 per cent in 1925.

It is somewhat disappointing to note that, although 1925 was a year of relative prosperity in the United States and depression in Great Britain, Germany, and a number of the other countries, still the activity of the industry in this country was only 74.5 per cent as contrasted with 87 per cent in Great Britain and 58 per cent in Germany.

In developing this material, Dr. Lange excluded electrotechnical products and boilers, but included locomotives. Obviously, a great deal of difficulty was encountered in developing this material because certain statistics are not available and certain other returns are in a form that is scarcely satisfactory. This subject is discussed in greater detail in the appendix accompanying the original memoranda.

TABLE 2 WORLD CONSUMPTION OF MACHINERY

(Current values)

	1913		1925	
	In millions of dollars	Per capita	In millions of dollars	Per capita
Total consumption	3,226		5,250	
1 *America:*				
United States	1,457	$15.11	2,731	$23.66
Canada	100	13.30	208	23.44
South and Central America	85	1.17	121	1.57
2 *Europe:*				
Great Britain	238	5.28	561	10.19
Germany	515	7.69	539	8.62
Russia	194	1.17	134	1.02
Austria-Hungary or Succession States	135	2.62	87	3.05
France	98	3.28	136	3.45
Other European countries which produce machinery	213	3.17	317	3.17
Other European countries	38	0.83	50	0.69
3 *Australasia: Asia:*				
Australia	36	7.85	66	11.07
New Zealand	6	5.71	11	8.00
India	33	0.10	54	0.17
China	5	0.14	21	0.05
Japan	26	0.48	91	1.52
4 *Africa:*				
Union of South Africa	15	2.50	24	3.36

World Consumption of Machinery

The degree to which the industries of the various countries have been mechanized can scarcely be determined from Table 1, because it is necessary to allow for the size of the country, its industrial development, its population, etc., in order to gain an accurate impression; but in order to show the rate at which machinery is being absorbed in the different countries, due correction being made for exports and imports, Table 2 has been prepared.

Considering not merely the working population, but instead the entire population of these several countries, it will be noted that in 1913 the United States absorbed $15.11 worth of machinery for each man, woman, and child in the country. By 1925, this value had increased to $23.66 per person—an increase of 56 per cent. In the United Kingdom, in 1913, the consumption of machinery was $5.28 per person, and in 1925 it was $10.19—an increase of 95 per cent. In Germany, the corresponding figures are $7.69 and $8.62—an increase of 13 per cent. In France, the consumption was $3.28 and $3.45—an increase of 5 per cent. When it is remembered that the liberal employment of machinery and power in industry increases the per capita production and, consequently, raises the standard of living of the people, it will be recognized that there is a very close connection between the rate at which machinery is absorbed in these several countries and the wage rates and standards of living to be found in them. It is gratifying to note the high degree of mechanization to be found in American industry. The rapid increase in Great Britain is significant, while the returns for countries like France indicate the small degree to which the industries of such countries have been mechanized and the directions in which progress is possible.

Parenthetically, it might be added that in "Eclipse or Empire?" a book published in London in 1916, it was pointed out that, on the whole, the horsepower employed per worker in the United

[1] The material here presented is a digest of memoranda submitted to the International Economic Conference held under the auspices of the League of Nations at Geneva in May, 1927. Most of this material is taken from the monograph submitted by the Verein Deutscher Maschinenbau-Anstalten (German Machinery Manufacturers' Association), although other memoranda were submitted from Great Britain, Austria, France, and Italy. The complete material is published in two volumes, copies of which can be secured from the World Peace Foundation, 40 Mt. Vernon Street, Boston, Mass., price $2.75. In fairness to the authors, it should be emphasized that the general picture of the machinery trade of the world here submitted is impressionistic and, at best, reveals the situation in a blurred fashion. It is to be hoped that in the course of time more satisfactory statistical material will become available and provide the means by which the present distorted image can be brought into sharp focus, supplying those interested with more dependable information regarding the subjects here treated. This is in no sense a criticism of those who prepared the reports, for the work has been most ably done, but it does seem necessary to emphasize that the statistical material available is not yet in a form that makes comparison possible or the preparation of a thoroughly satisfactory report feasible.

States is on the average about three times as great as in Great Britain; also, that American workers produce from two to three times as much product per year as do British workers. There appears to be an intimate connection between the degree to which industry is mechanized and the industrial efficiency of the people. Labor in the United States is paid, say, two and a half times the British wage, three times the German wage, and ten or twenty times the Oriental wage. The mere amount of power absorbed in industry is probably a poor basis for comparison, but it would be most interesting if it could be demonstrated that the amount of machinery per workman in American industry was also two and a half times the amount available in Great Britain, three times that available in Germany, and ten to twenty times that available in the Orient.

Number Employed

An effort was also made to prepare a table showing the number employed in the industries of "mechanical construction" for each of these countries in the years indicated, but again there is considerable difficulty with the statistical material available. However, approximations were made on the basis of various assumptions which are described in detail in the original reports but which yield the results shown in Table 3.

It is rather gratifying to observe that in 1925 the number of workmen employed in the United States, Great Britain, and Germany was in each instance very close to one-half million, although the value of the output in the United States was more than four times as great as in either of the other countries.

TABLE 3 NUMBER OF WORKMEN EMPLOYED IN THE WORLD'S MECHANICAL-ENGINEERING INDUSTRY

	1913		1925	
	Number of workmen	Percentage of total	Number of workmen	Percentage of total
1 *America:*				
United States	620,000	32.8	582,000	28.3
Canada	40,000	2.1	40,000	1.9
2 *Europe:*				
Great Britain	330,000	17.4	500,000	24.4
Germany	460,000	24.3	452,000	22.0
Russia	130,000	6.9	98,000	4.8
Austria-Hungary or the Succession States	80,000	4.2	66,000	3.2
France	45,000	2.4	85,000	4.1
Italy	30,000	1.6	35,000	1.7
Belgium	24,000	1.3	25,000	1.2
Switzerland	42,000	2.2	45,000	2.2
Sweden	25,000	1.3	20,000	1.0
Other European countries	30,000	1.6	40,000	1.9
3 *Australasia: Asia:*				
Australia and New Zealand	15,000	0.8	20,000	1.0
Japan	20,000	1.1	47,000	2.3
Total	1,891,000	100.0	2,055,000	100.0

Output per Worker

By combining the results of Tables 1 and 3, it is possible to arrive at the value of the product per worker in these industries for the different countries and years. This is shown in Table 4.

Table 4 shows clearly that considering only current prices the industry in all countries seems to have shown marked progress, but when the value of the output is corrected to allow for the difference in the value of money in 1925 as compared with 1913, it is shown that in the United States and Japan, for instance, there has been marked progress, while in Great Britain, Germany, France, etc., there has been a serious falling off, in some instances exceeding 30 per cent. Obviously, Europe is suffering from the economic disturbances resulting from the war. There has been a sharp decrease in efficiency in the machinery-producing factories there, but a pronounced improvement in this country. This provides some exceedingly interesting suggestions regarding the position of the United States in the machinery export trade, and the policies to be employed when confronted with competition from these various countries.

TABLE 4 WORLD MACHINERY OUTPUT PER WORKER EMPLOYED

	1913	1925	
	At 1913 prices	At 1913 prices	At 1925 prices
1 *America:*			
United States	$2,600	$3,462	$5,192
Canada	1,900	2,825	4,225
2 *Europe:*			
Great Britain	1,155	956	1,432
Germany	1,448	1,018	1,527
Russia	869	653	980
Austria-Hungary or Succession States	1,363	803	1,197
France	1,400	976	1,459
Italy	1,400	1,171	1,771
Belgium	1,542	1,040	1,560
Switzerland	857	1,000	1,511
Sweden	1,160	1,350	2,000
Other European countries	1,067	950	1,425
3 *Australasia: Asia:*			
Australia and New Zealand	1,200	1,200	1,800
Japan	550	723	1,085
World average	$1,706	$1,703	$2,555

Wages

A corresponding table (Table 5) is available comparing the wages paid to both skilled and unskilled labor in these countries at the dates indicated. This table, like most of the others, is imperfect because of the inadequate statistical material from which it was developed and the variation in wages paid from district to district, city to city, and trade to trade. On the other hand, there is a certain justification in republishing it, and in a limited way it expresses the situation described.

All of the preceding emphasizes the outstanding position of the United States in the machinery industry of the world—the high output per worker, the high wages paid to American labor, and a somewhat favorable output per unit of wages.

International Trade

While the world's production of machinery in 1925 was about $5,250,000,000, the volume that entered international trade was about $875,000,000—a total indicating an exceedingly large

TABLE 5 WAGES IN THE MECHANICAL-ENGINEERING INDUSTRY

(In dollars per week)

	Skilled			Unskilled		
	1913–14	End of 1925	End of 1925 expressed as percentage of 1913–14	1913–14	End of 1925	End of 1925 expressed as percentage of 1913–14
1 *America:*						
United States (actual earnings)	14.84	30.78	207	10.89	24.43	224
Canada (wages scale)	19.28	30.58	161	...	...	..
2 *Europe:*						
Great Britain (time-rate wages scale)	9.93	14.33	144	5.54	9.74	176
Germany (wages scale)	8.79	11.00	126	5.60	7.42	132
Austria (wages scale)	5.66	5.74	101	4.25	4.79	113
Hungary (average wages)	6.85	...	..	3.58	...	..
Czechoslovakia (wages scale)	...	8.11	..	...	4.60	..
France (actual earnings)	...	8.51	..	...	5.19	..
Italy (wages scale)	...	6.81	..	...	5.26	..
Belgium (wages scale)	6.75	7.43	110	3.98	5.03	126
Switzerland (actual earnings)	7.35	14.10	192	5.64	10.81[1]	192
3 *Australasia: Asia:*						
Australia	16.87	26.36[1]	156	11.50	20.27[1]	180
New Zealand	15.71	20.30	129	...	...	..

[1] 1924.

The average earnings of Russian metal workers (skilled and unskilled) are given as $3.99 in 1913 and $10.35 in 1925, an increase, therefore, of 159 per cent.

In Sweden the average weekly earnings of skilled and unskilled workers averaged $6.66 in 1913 and $14.76 in 1924, which means an increase of 116 per cent.

market and one that should be of great interest to American manufacturers. The participation of the more important countries is shown in Table 6.

It is rather startling to observe that in spite of the present leading position of American manufacturers in the production of machinery, as conditions were in 1913, the United States, Great Britain, and Germany enjoyed a substantially equal share of this business. By 1925 conditions had changed, the American position showing marked improvement but in no sense measuring the position of American machinery in the world's markets. Since America produced 57 per cent of the world's total output of machinery, it appears somewhat difficult to understand why it obtained but one-third of the international machinery trade of the world.

TABLE 6 EXPORTS OF MACHINERY THROUGHOUT THE WORLD

	1913		1925				
			At 1913 prices			At current prices	
	Millions of dollars	Per cent	Millions of dollars	Per cent	Increase, 1913 to 1925	Millions of dollars	Increase, 1913 to 1925[1]
1 *America:*							
United States	162	26.8	203	34.8	25.3	305	88.0
Canada	9	1.5	12	2.1	33.3	18	100.0
2 *Europe:*							
Great Britain	172	28.4	143	24.4	−16.9	214	24.4
Germany	176	29.0	117	20.0	−33.5	175	−0.5
Austria-Hungary, or Succession States	7	1.1	15	2.7	114.3	23	228.6
France	18	3.0	27	4.6	50.0	40	122.2
Italy	4	0.7	4	0.7	....	6	50.0
Belgium	15	2.5	9	1.6	−40.0	14	−6.7
Switzerland	15	2.5	20	3.4	33.3	30	100.0
Sweden	12	1.9	14	2.4	16.7	21	75.0
Other European countries	13	2.3	16	2.8	23.1	24	84.6
Australasia: Asia:							
Australia and New Zealand	1	0.1	0.7	0.2	....	1	...
Japan	1	0.2	2	0.3	100.0	3	200.0
Total	605	100.0	583	100.0	−3.6	874	44.5

[1] Some discrepancies occur here as compared with the original table, as the basis of the latter is millions of marks, whereas the basis used here is millions of dollars.

Table 6 also indicates how the British and German manufacturers experienced difficulty in maintaining the position in the world's markets that they had previously held, German participation showing the more marked reduction.[2]

In considering the above returns allowance should be made for a number of factors. For example, it is found that in the machinery import trade of Italy, American machinery commands a price per ton approximately three times as great as that for Great Britain, Germany, or France. Using the returns of Dr. Lange's monograph, it is possible to compute the values given in Table 7.

TABLE 7 VALUE PER TON OF MACHINERY EXPORTED FROM THE VARIOUS COUNTRIES

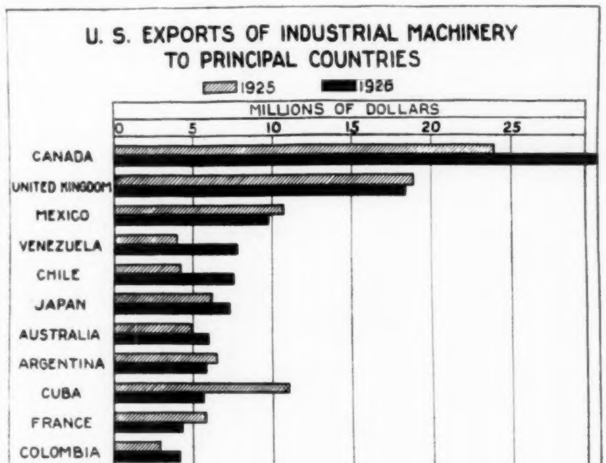
	Absolute value	Relative value, per cent
United States	$552	100
Switzerland	510	92
England	405	73
Germany	325	59
France	267	48.5

This provides a rather startling commentary on the machinery export trade of the United States. Obviously, American machinery is the quality product. It enjoys a unique prestige in the world's markets. But these returns further indicate that this high-quality, high-priced machinery can only be successfully marketed abroad when supported by adequate, constructive salesmanship.

Inasmuch as the most serious competition is felt from Germany and Great Britain, full allowance should be made for the price difference represented by these returns, but it also should be remembered that the United Kingdom regularly imports about $18,000,000 worth of American machinery annually, while Germany imports between $3,000,000 and $5,000,000 per year. These facts indicate the high esteem with which the better grades of American machinery are received in those countries.

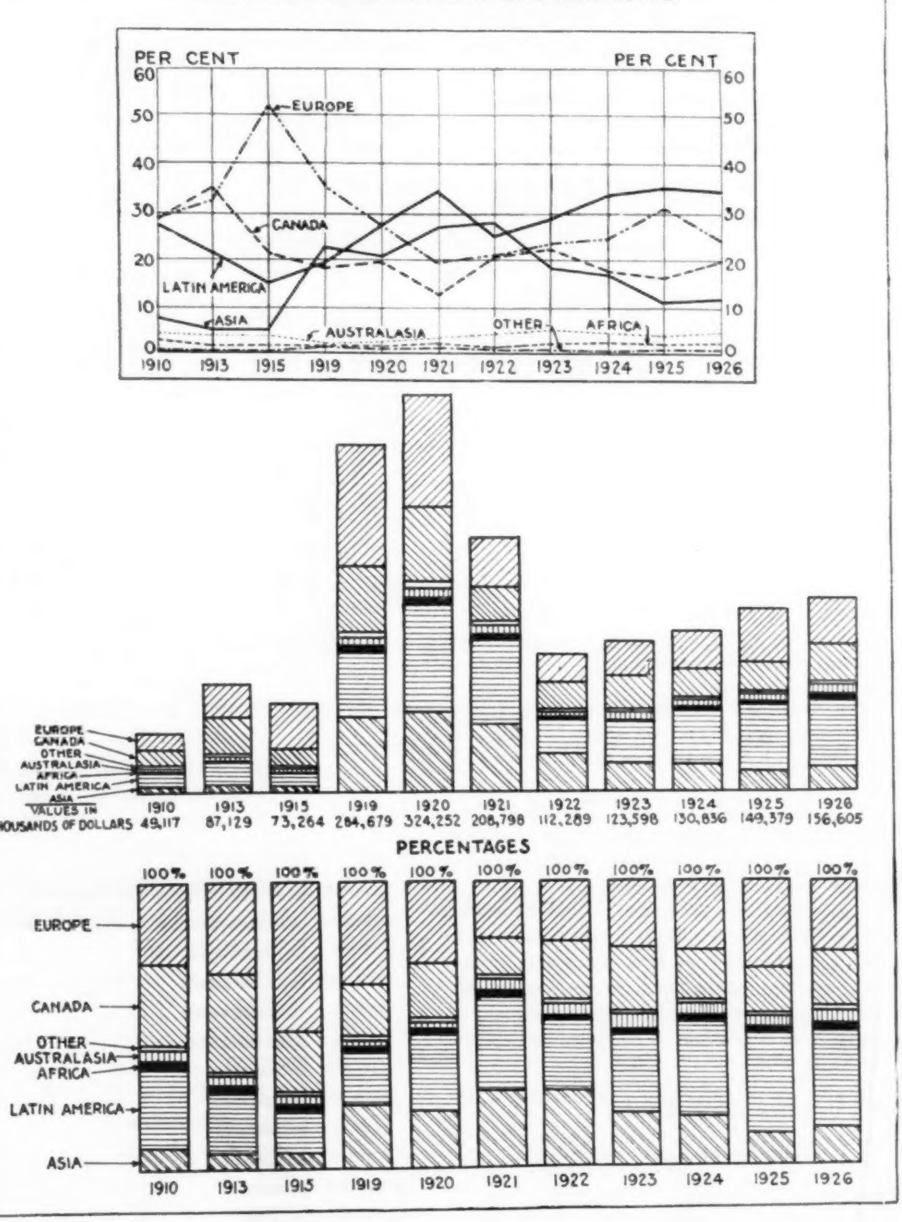
Export Ratio

This study also provides some interesting information regarding the extent to which manufacturers in the different countries profit from export business. There are important American companies handling heavy machinery which will regularly export more than 50 per cent of their production. There are important manufacturers in Great Britain that regularly export as much as 70 per cent. These companies find such foreign business peculiarly valuable, for in addition to supplying an increased volume of business that is unusually attractive because it is sold under conditions that provide for prompt payment and a minimum of service, it also provides a diversity factor which stabilizes their business



[2] It will be noted that the figures in Table 6 differ radically from those published elsewhere on different occasions. It is inevitable that marked discrepancies should develop in connection with work of this kind because of the unsatisfactory nature of the statistics upon which they are based. It should also be remembered that different authors employ different classifications of machinery in making these comparisons. For example, if lawn mowers, typewriters, office and household machinery, and certain other classes were omitted, there would be a very different result.

CHANGES IN DESTINATION OF UNITED STATES INDUSTRIAL MACHINERY EXPORTS



during periods when there is depression in their own country. As has been previously indicated, there is reason to feel that the figures given in this report can be criticized because the statistical material upon which they are based has not been found entirely satisfactory, but according to these returns the export ratios of the various countries were as given in Table 8.

TABLE 8 EXPORT RATIOS OF DIFFERENT COUNTRIES

(From *Iron Age*, June 30, 1927)

	1913, Per cent	1925, Per cent
United States	10	10.1
Great Britain	45	29.8
Germany	26.4	25.3
Other countries	16.7	22.1
World	18.7	16.7

It should be emphasized in connection with all of the returns above mentioned that a great deal depends upon the classifications employed. The United States, for example, has been credited in 1925 with machinery exports totaling $305,000,000, but if locomotives, typewriters, agricultural implements, and household and office machinery are excluded, and we consider only the machinery used in factories, mines, and on construction work, it will be noted that in 1925 the United States exported only $150,000,000. But in view of the large domestic consumption of the excluded items just mentioned, the export ratio increases materially. There is reason to believe that for strictly industrial machinery, American manufacturers export about 20 per cent of their production. Table 11 shows the experience in various sections of the machinery industry for the years indicated.

TABLE 9 UNITED STATES EXPORTS OF INDUSTRIAL MACHINERY

(In thousands of dollars)

	Fiscal years			Calendar years							
Destination	1910	1913	1915	1919	1920	1921	1922	1923	1924	1925	1926
Canada, Newfoundland, etc.	14,113	30,637	15,449	52,346	63,157	26,966	23,010	27,719	23,297	24,134	31,072
Europe (except Balkans)	14,149	27,683	38,219	100,397	90,731	41,100	23,236	28,427	32,159	45,688	38,342
South America	4,309	7,739	4,457	24,048	28,736	23,181	11,385	14,965	19,247	26,328	34,685
Mexico and Central America	6,412	6,209	2,590	11,144	21,235	23,373	9,609	9,608	11,524	13,005	11,721
West Indies	2,763	4,877	4,013	10,369	38,387	23,780	7,026	10,254	12,701	13,100	7,561
Total Latin America	13,484	18,825	11,060	54,561	88,258	70,334	28,020	34,827	43,472	52,433	53,967
Asia (except Asia Minor)	3,666	4,377	3,777	61,880	65,308	55,599	31,037	22,577	21,826	16,582	19,249
Australasia	2,200	3,560	2,987	5,672	8,044	7,605	4,516	6,476	5,774	6,039	7,425
Africa	1,353	1,592	1,490	5,183	5,314	4,487	1,564	2,543	3,358	3,251	4,539
Other countries	152	455	282	4,640	3,440	2,707	906	1,029	950	1,252	2,011
Grand total	49,117	87,129	73,264	284,679	324,252	208,798	112,289	123,598	130,836	149,379	156,605
Percentage to:	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Latin America	27.5	21.6	15.1	19.2	27.2	33.7	24.9	28.2	33.2	35.1	34.5
Asia	7.4	5.02	5.2	21.7	20.1	26.6	27.6	18.3	16.7	11.1	12.3
Canada, Newfoundland, etc.	28.7	35.3	21.1	18.4	19.5	12.9	20.5	22.4	17.8	16.2	19.8
Europe	28.8	31.9	52.2	35.2	28.0	19.7	20.7	23.0	24.6	30.6	24.5
Australasia	4.5	4.1	4.0	2.1	2.5	3.6	4.1	5.2	4.4	4.0	4.7
Africa	2.7	1.8	2.0	1.8	1.6	2.2	1.4	2.1	2.6	2.2	2.9
Other countries	0.4	0.5	0.4	1.6	1.1	1.3	0.8	0.8	0.7	0.8	1.3

TABLE 10 COMPARATIVE VALUE OF THE FOREIGN MARKETS FOR AMERICAN MACHINERY

	1926		1925		1924		1923		1922	
	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value
Canada	1	$30,850,429	1	$23,885,370	1	$22,840,161	1	$27,371,084	1	$22,897,812
United Kingdom	2	18,395,212	2	18,789,152	2	15,132,859	2	14,517,848	3	12,791,732
Mexico	3	9,758,431	4	10,777,422	5	9,178,880	5	7,827,323	4	8,741,456
Venezuela	4	7,784,119	12	3,919,921	17	1,949,961	18	1,322,978	19	927,307
Chile	5	7,558,810	11	4,229,852	11	3,052,885	10	2,575,942	16	1,171,843
Japan, including Chosen	6	7,215,679	6	6,254,216	3	10,626,051	3	11,832,100	2	14,256,017
Australia	7	6,151,717	9	4,954,743	8	4,544,860	6	5,497,986	9	3,687,797
Argentina	8	5,863,358	5	6,460,730	7	5,046,139	9	3,874,848	10	3,583,125
Cuba	9	5,614,717	3	11,051,484	4	10,182,404	4	8,253,402	6	5,730,320
France	10	4,418,786	8	5,832,117	6	5,744,549	7	5,345,461	8	4,715,561
Colombia	11	4,178,257	16	2,844,692	15	2,195,793	17	1,792,940	13	1,537,239
Soviet Russia in Europe	12	4,114,946	14	3,678,141	25	956,019	32	430,855	47	64,342
Brazil	13	3,969,833	10	4,705,776	9	3,336,742	12	2,152,525	11	2,480,239
Peru	14	3,494,439	17	2,428,149	16	2,093,237	14	1,981,251	15	1,179,748
Germany	15	3,197,895	7	5,930,786	13	2,590,402	25	763,553	23	565,835
India, British	16	3,160,834	15	3,258,087	10	3,288,568	8	3,984,008	7	5,390,227
Dutch East Indies	17	3,028,716	20	2,033,246	21	1,454,854	24	795,766	35	291,731
British South Africa	18	3,022,607	18	2,176,445	14	2,488,859	15	1,855,834	17	1,075,213
Italy	19	2,013,736	13	3,811,202	20	1,465,756	22	865,489	24	559,084
China	20	1,979,881	22	1,514,788	19	1,817,491	11	2,222,036	5	8,251,768
Philippine Islands	21	1,890,146	21	1,691,954	12	2,910,849	13	2,127,955	12	1,632,404
Spain	22	1,384,222	19	2,122,986	18	1,897,776	16	1,839,934	14	1,370,868
Rumania	23	1,318,275	33	495,200	45	274,898	31	438,783	28	396,335
New Zealand	24	1,220,048	24	1,014,048	23	996,456	20	954,948	20	808,918
Belgium	25	1,020,877	27	924,307	24	968,770	19	1,164,720	18	1,099,607
British Malaya	26	961,346	..	......	..	......	..	......	..	......
Sweden	27	847,506	26	981,824	30	609,103	26	614,056	29	390,832
Bolivia	28	684,127	29	691,359	28	673,221	27	600,000	31	336,985
Netherlands	29	656,016	23	1,155,687	26	827,881	21	866,988	21	691,696
Dominican Republic	30	647,276	28	842,718	22	1,348,765	23	813,190	22	576,892
Panama	31	600,436	31	500,212	27	692,614	30	466,324	36	287,415
Portuguese East Africa	32	585,127	30	609,250	46	274,514	39	278,001	41	163,103
Trinidad and Tobago	33	580,209	39	324,660	39	335,441	34	380,292	26	404,593
Uruguay	34	565,152	34	454,569	41	307,204	42	230,595	37	277,523
Soviet Russia in Asia	35	522,766	..	......	..	......	..	......	..	......
Norway	36	474,528	32	496,500	42	298,772	37	316,641	38	252,028
Salvador	37	408,203	41	301,899	33	421,344	47	115,747	40	169,585
Guatemala	38	373,035	35	447,719	44	277,476	40	274,486	43	149,687
Finland	39	358,285	44	284,989	36	347,678	48	98,966	48	43,815
Denmark	40	304,979	47	257,940	43	295,331	38	306,451	34	310,663
Greece	41	289,783	..	......	..	......	..	......	..	......
Poland and Danzig	42	277,098	40	302,060	37	345,290	35	361,740	39	232,352
Dutch Guiana	43	264,095	..	......	..	......	..	......	..	......
Belgian Congo	44	234,263	..	......	..	......	..	......	..	......
Kwangtung	45	231,652	37	415,773	31	487,007	44	194,908	32	313,712
Dutch West Indies	46	225,690	43	295,430	21	1,454,854	24	795,766	35	291,731
Newfoundland	47	220,710	49	245,491	32	455,003	36	347,256	45	110,874
Switzerland	48	207,229	38	392,494	48	198,564	46	137,357	44	127,045
Ecuador	49	204,274	45	270,054	35	374,347	41	252,753	33	311,034
Nicaragua	50	195,223	36	420,860	40	326,187	43	201,802	46	104,510
Honduras	51	193,162	48	255,930	34	389,619	29	508,280	25	432,708
Algeria and Tunisia	52	163,049	..	......	..	......	..	......	..	......
Haiti	53	159,182	..	......	..	......	..	......	..	......
Egypt	54	156,156	..	......	..	......	..	......	..	......
Costa Rica	55	154,487	46	261,981	47	240,558	45	156,577	42	151,064
Hongkong	56	136,165	50	239,750	38	337,887	33	410,886	30	346,614
Straits Settlements	..	......	25	993,377	29	657,406	28	534,786	27	400,708
Czechoslovakia	..	......	42	296,963	49	121,021	49	71,667	49	12,876
Total, including other countries		156,604,926		149,379,238		130,836,318		123,598,127		112,288,922

It will be remembered that 1921 was a year when export business was heavy and domestic business relatively light, while in 1923 there was a depression in the export situation and comparative prosperity in the domestic situation, with the result that there are startling differences in the percentages exported in these two different years. However, for the purposes of making business plans for developing sales campaigns or for preparing budgets, it is probably in order to assume that on the average American machinery manufacturers can and should export 20 per cent of their production, and in considering export business, to remember that according to this German report the international machinery trade of the world absorbs

$875,000,000 worth of equipment annually—a market well worth careful attention.

The Machinery Export Trade of the United States

The experience of American machinery exporters during recent years is shown in Table 9, from which it will be noted that the volume exported increased from about $49,000,000 in 1910 to $156,000,000 in 1926.[3]

Throughout the period this trade showed consistent and satisfactory growth, except that in the period between 1915 and 1921 it was greatly stimulated. The returns also indicate the ways in which these shipments were distributed, and it is interesting to note that the Latin-American group of countries have for several years absorbed about one-third of these exports, the European group about one-fourth, Canada and Newfoundland about one-fifth, and the countries of Asia about one-eighth.

The returns in Table 9 will provide a general basis that can be used in developing plans for any export campaign covering this line. The volume of the market, the directions in which the trade flows, the expansion or contraction in the different areas, are quite clearly indicated.

In order to provide further details along this line, returns are given in Table 10 for each of the more important countries, between the lines of which may be read the complete story of recent economic history. The ups and downs of the trade in Europe, Latin America, and Asia make a very interesting story. For example, there is the case of Russia where it will be noted that the business expanded from $64,000 in 1922 to $4,100,000 in 1926, and to this should be further added the shipments to Asiatic Russia of $522,000 in 1926.

The experience in the Dutch East Indies is also interesting, the business there having expanded from $291,000 in 1922 to $3,000,000 in 1926. Venezuela expanded from $927,000 in 1922 to nearly $8,000,000 in 1926; Chile from $1,100,000 in 1922 to $7,500,000 in 1926. Sometimes this may be a story in petroleum, sometimes in copper or nitrate. At any rate, it is obvious that the international machinery trade of the world absorbs $875,000,000 worth of machinery a year, which should be most interesting to American machinery manufacturers, as it represents about 30 per cent of the volume of our total domestic demand and is growing very rapidly.

TABLE 11 PERCENTAGES OF PRODUCT EXPORTED BY VARIOUS SECTIONS OF THE MACHINERY INDUSTRY

	1921	1923
Oil-well machinery	41.2	12.7
Mining machinery	25.0	21.3
Air compressors	24.8	9.4
Metal-working machinery	22.2	6.9
Shoe machinery	19.0	10.7
Flour- and grist-mill machinery	18.6	12.7
Pumps and pumping	17.1	8.0
Textile machinery	15.3	7.1
Woodworking machinery	13.8	3.5
Dredging and excavating machinery	12.7	4.0
Laundry machinery (power)	10.4	6.6
Paper- and pulp-mill machinery	9.5	6.6
Concrete mixers	6.7	3.9
Ice and refrigerating machinery	5.8	6.2
Road-making machinery	5.5	3.3
Cotton gins	4.3	4.4
Elevators and elevating machinery	3.2	2.3

The Industrial Machinery Division of the Bureau of Foreign and Domestic Commerce was organized by the Government to promote the interests of American machinery manufacturers, and there is every reason to believe that the volume of foreign orders can easily be increased to a much larger total than now exists. The Division is prepared to cooperate with the individual manufacturer in the developing and in the solution of problems that may arise in connection with export trade. Communications are invited.

[3] Unlike figures given elsewhere, these statistics cover only industrial machinery and exclude electrical equipment, locomotives, office and household machinery, etc.

Gray-Iron Castings Heat Treated

Gray-iron castings used by the Ford Motor Co., Fordson, Mich., for several of the smaller parts of its motor cars are heat treated in continuous furnaces before machining to eliminate hard spots, produce a fine grain structure, make the metal softer and easier to machine, and consequently speed up production in machine work on the castings. Some of the light castings, particularly carburetor castings, require small drill holes. After the annealing operation, drilling is done more rapidly and there is less breakage of drills.

The permanent-mold process is used in making some of the small castings that are heat treated and others are made in sand molds. Castings made in permanent molds that are heat treated before machining include generator heads, timing gear housings and certain valves for automobiles, tractor pistons, timing gear blanks for tractors, and various miscellaneous parts for plant equipment, such as conveyor wheels.

The permanent-mold castings are poured on circular revolving platforms in iron molds. When shaken from the molds and still red hot they are dumped on plate-type carriers 10 in. wide and 34 in. long and are moved through a furnace with a rocker-arm type of pusher. The furnace is 25 ft. long. The castings are usually kept in the furnace 80 min. The heating temperature is found to be more satisfactory at 1650 deg. fahr., although castings have been heat treated at 1500 deg. by keeping them in the furnace a longer time and they are sometimes given a longer soaking time at around 1650 deg. to produce a softer metal. At times the furnace temperature is increased to 1700 to 1750 deg. to shorten the operation and increase the furnace output. In case cold castings are charged into the furnace the heating operation takes approximately 2 hr.

The usual Brinell hardness of the castings after heat treating is 187, but there is a hardness range of from 177 to 207 depending on the type of castings. Some that require particularly soft metal for machining have a hardness of 177, while pistons have a higher Brinell hardness.

Three duplicate furnaces are used for heat treating the permanent-mold castings. These have a capacity of 30 tons in an 8-hr. day, handling the output of eight permanent-mold molding machines. The furnaces are gas-fired with four burners on each side and are equipped with automatic heat regulators and recording charts.

From the discharge end of the furnace the castings are dumped into an adjoining elevator and taken to a cleaning room on the second floor. When they have reached that floor, they have cooled sufficiently to go into tumbling mills for removal of fins and scale. They are tumbled from 20 to 30 min., which, it is stated, is only one-fourth of the time required for tumbling similar castings made in sand molds.

Sand castings that are heat treated before machining include bushings and several of the small parts for carburetors. These castings, on leaving the furnace, go to tumbling mills and then to the machine shop. Two furnaces are provided for heat treating these castings, these being practically identical with those used for heat treating permanent-mold castings. The sand castings are left in the furnace from 2 to 3 hr. After having received heat treatment, they have a range in Brinell hardness of 143 to 207.—*Iron Age*, vol. 121, no. 10, Mar. 8, 1928, pp. 663–664.

The New Competition

Typical Examples of the Contributions of Science to the New Competition in Which Organized Industries Strive Among Themselves for the Consumer's Dollar

By H. E. HOWE,[1] WASHINGTON, D. C.

A FEW years ago a conversation between a New York banker and the managing editor of the *Nation's Business* resulted in the coining of the phrase "The New Competition." This is intended to describe competition of the present day, in which organized industries strive for the dollar spent by the consumer, in contrast with the efforts of individual purveyors to obtain a like dollar a few years ago. While industries are rapidly becoming grouped in the new competition and we see the evidences of the result on every hand, the consumer has no appreciation of what underlies the competition of today, and indeed those engaged in it seldom pause to remember that it is the contributions of science which have brought it all about.

In an address before the American Chemical Society in Detroit [*Industrial and Engineering Chemistry*, vol. 19 (1927), p. 1212], C. F. Kettering emphasized that it is the business of those engaged in research to keep every one reasonably dissatisfied with what they have by the simple process of creating new products more desirable than those now in possession of the public. It is this flow of new ideas which is responsible for industrial prosperity—not the mere flow of money.

The object here is to call attention to a few typical examples of the contributions of science to the new competition and to give some superficial information concerning them, that engineers may become somewhat acquainted with work, much of which is perhaps outside their immediate field.

Consider an ordinary Irish potato. The earliest ones command the highest prices and generally come from Bermuda or some equally favored locality. The seed for these potatoes preferably comes from another climate and is usually imported from certain parts of the United States. If you have farmed, you know that the life cycle of the potato involves a resting period after maturity before it is satisfactory for seed, and the length of this rest period is an important factor in determining how early the potato crop will be. A number of years ago Dr. F. E. Denny, who was called upon to investigate the cause of certain greenhouse troubles with carnations, learned that ethylene caused the phenomenon he was studying, and as a result became interested in the effects of chemicals upon life cycles of plants and flowers. His researches led to the employment of ethylene in imparting a desirable color to oranges that were ripe but appeared green, and the employment of the same reagent with lemons. Turning his attention to the potato, he has found that by treating the seed potatoes with such reagents as ethylene chlorhydrin, the rest period can be greatly shortened—from weeks to days. The economic result is that we shall soon find Florida competing with Bermuda in the early-potato market, and shall have an excellent example of the new competition, brought about primarily through the application of chemistry.

A newcomer among the dried-fruit products is dried citrus-fruit juice, prepared by much the same process and by the same company responsible for Klim, the popular brand of dry milk. Orange juice and lemon juice, dried with a little corn sugar which aids the drying, are available as flavors, while a product prepared from fresh lemon juice makes possible the instant preparation of a high-grade lemonade in no wise synthetic. The preparation of these dried products introduces another economic factor in caring for excess fruit, and for undersized, misshapen, or discolored fruit not ordinarily available for market and yet a real value as food. The possibility of using such fruits in this manner and for the production of pectin, oils, and citric acid is of great importance in price stabilization and waste prevention.

New Chemical Raw Materials

New competitors frequently put in an appearance among chemical raw materials. They not only afford the consumer a choice in selecting raw materials, but often win their own markets because of individual characteristics. Furfural, made from by-product oat hulls, is an example. Not enough is yet known concerning the chemical and physical characteristics of this compound to indicate all possible uses, but we find it employed as a solvent, as a disinfectant, as a raw material for dyes, as a competitor of formaldehyde, etc. A striking use is the preparation of a photosensitive resin, through the medium of which designs can be etched upon metals, giving a pattern quite as satisfactory as we usually obtain by mechanical means.

Synthetic methanol, now manufactured in this country from carbon monoxide and hydrogen, derived from coal, is a direct competitor of refined methanol, and is destined to play a vital part in the cost of synthetic resins, themselves an excellent example of the new competiton. All methanol until a few years ago was made by the destructive distillation of hardwood, but the laboratory has developed methods for production at far lower costs, which means in turn cheaper formaldehyde and cheaper synthetic resins.

Bakelite is our outstanding example of the new resin and is familiar in its many forms. Mechanical engineers need no reminder of this new structural material, one which competes with certain metals and plastics and yet is not only a competitor but a new structural medium. The ability to mold it with metal parts in place and use its products as they come from the press without further trimming, polishing, or finishing, has made it a favorite for too great a variety of uses to be catalogued here. Bakelite has its competitors, affording us an illustration of the demands of modern construction, where a variety of products are produced, each to meet a special use, and yet overlapping and competing to a certain extent with other materials. Karolith, a casein plastic, is such a material. It is adaptable to a great range of colors, is easily worked by mechanical means, and finds an outlet in ornamentation, as handles, fountain-pen barrels, buttons, ad infinitum.

New methods of using old materials are equally important, and we may soon expect to see the electrodeposition of rubber carried on commercially. Having always regarded rubber as one of our best insulators, it is difficult to realize that means have been devised for depositing rubber from latex upon metal surfaces and having compounding materials in proper proportions for vulcanization plated out with the rubber. Large-mesh rubber screens have been coated in this manner. Various surfaces have likewise been electroplated with rubber. Many

[1] Editor, *Industrial and Engineering Chemistry*.

Substance of an address delivered at the annual banquet of The American Society of Mechanical Engineers, Hotel Astor, New York, December 7, 1927. Numerous products were exhibited during the course of the address.

mechanical rubber articles have thus been produced, and inner tubes have been built up by electrodeposition.

Cellulose the Most Interesting Chemical Raw Material of the Future

For more than a generation coal tar has occupied the center of the chemical stage as an outstanding raw material of chemical industry. There is no indication that its importance will diminish, but we see cellulose developing as the most interesting chemical raw material of the coming generation. It may be derived from second-cut cotton linters and from wood, while experiments in process may indicate the feasibility of obtaining it in satisfactory quantity and quality from annual-growing stalks like those of corn.

Whatever its source, so long as quality is satisfactory, it becomes the starting point of diverse products. In solution cellulose may be reconstituted as such in the form of films of the cellophane type. This material can be had from 8 to 64 ten-thousandths of an inch in thickness and is most familiar in the thinner sheets. This we recognize on every hand as the modern wrapping material, by means of which every object can be placed in its own show case. Colorless, or in a variety of colors, smooth surface or embossed, and lately supplied in moistureproof form, it finds its own special uses. Its place in competition is evident, for one candy manufacturer employing it for a chocolate bar was able in two months to increase his business one thousand per cent. The public likes to see what it buys, and is still more pleased if it finds it protected from human touch, from germs, from dust, and from moisture.

Cellulose Lacquers

Another familiar cellulose film is the Duco type of modern lacquer, the development of which was largely in response to an economic urge. C. F. Kettering of the General Motors Corporation related the story. Recognizing the economic loss involved in the finishing of a fine car, which took from 26 to 28 days, he asked the paint and varnish manufacturers to help him reduce this time factor. After conference, they reported that if certain changes in specifications would be acceptable, the time could be reduced to 24 days, but they were told that what was wanted was 24 hours. They replied that it was impossible, for paint and varnish dry too slowly. Giving further thought to the big problem, Mr. Kettering decided to try the type of lacquer used to protect silverware on display from the tarnishing sulphides of the air, but the manufacturers of that lacquer discouraged him, saying that he could not lacquer a car with such material, for it dried too quickly. What would you do in similar circumstances? Mr. Kettering turned to research, and Duco is the result.

Some time later the president of a great paint company called to lunch with Mr. Kettering, driving up in a fine car. In the course of the conversation he was asked what color he would choose if his car were to be refinished, and asked to indicate his choice among a group of samples taken from Mr. Kettering's desk. He replied that he had no intention of refinishing his car, but when the time came he would choose such and such a color, indicating his choice. When they returned from lunch, his car, fully refinished in the new color, stood at the door.

Artificial Leather

A familiar cellulose film is that used in the manufacture of "fabrikoid," a familiar artificial leather. It has been said that if we were required to use real leather for all the purposes to which this material is put, we should have to slaughter yearly twice as many cattle as we ever have at one time in the United States. The foundation material is a specially prepared cotton (cellulose) fabric. Upon this are applied many coatings of cellulose in solution, together with suitable pigments, and it is finally embossed with the design.

Another film of economic importance is the Visking sausage casing, developed after seventeen years of research and investigation in an effort to find a more acceptable package for sausage. This again is a triumph of patience and research, and even after the tube of viscose, reconstituted as cellulose, had been perfected, the work continued until methods of using had been perfected. Now made at the rate of more than 17 miles per day, its great popularity is due to its part in perfecting the no-skin frankfurters. When sausage in a natural casing is smoked, the meat is slightly tanned, the natural casing being tanned with it. Afterward they are very difficult to separate. When smoked in the visking casing, the meat is tanned as before, but the casing is unaffected and is stripped from the sausage before packaging for the market. The sausage holds its shape throughout the merchandizing operations and preparation for serving. The popularity of the frankfurter without the casing is growing rapidly.

Rayon

Another cellulose product important in the new competition is the modern rayon yarn and fabric. Some of this is made from cellulose derived from wood, and some from that derived from cotton linters. In both cases the cellulose is brought into solution, treated according to the process or product in a given case, and then forced through a spinneret into a chemical setting bath, in which the material is insoluble. Precipitation occurs and is the basis of the thread, which is reeled out of the bath, cleaned, bleached, dyed, or otherwise treated. World production of rayon in 1926 is put at 219,080,000 pounds, and that for 1927 at 265,900,000 pounds. Of this 65,825,000 pounds were made in North America in 1926, and 74,500,000 pounds in 1927.

The popularity of rayon is due among other things to the preference of the silk manufacturer to buy from a producer in his own country, thereby freeing himself from the many uncertainties influencing the natural-silk market. Then, too, encouraging success has met the efforts of the rayon manufacturer to provide a thread of improved strength and one fine enough to enable weaving the sheer fabrics demanded by the fashion of the day. Celanese, which is one of the cellulose acetates, has proved particularly acceptable for some of the printed lightweight materials, as well as for satins and pile fabrics.

Cellulose itself, unchanged from the wood, has also entered the new competition. Mr. Mason of Laurel, Miss., has succeeded in preparing a pulp by treating chips under high pressure and then suddenly releasing that pressure, so that the steam produced between the fibers suddenly expands, resulting in a fluffy pulp in which the original lignins are present. After brief beating, this pulp is run out on a paper-making machine, cut into suitable lengths, and made into an insulating board by drying under pressure in a steam-heated hydraulic press. By increasing the pressure, a more dense board with fine finish is prepared. Such materials compete not only with other types of insulating board, but with certain types of lumber itself.

In cellulose, competition is not wholly between men. The great losses caused by the activities of the marine borer are well known. Untreated piling will be destroyed in three months or less, and even treated piling has been of uncertain life. Great losses on the West Coast due to the teredo reawakened interest in the problem, and one of the peace-time contributions of the Chemical Warfare Service has been the development of a special impregnating compound. This is one of the war gases, diphenylaminechlorarsine, in a petroleum vehicle, and tests now more than three years old indicate this to be one of the best materials for protecting marine structures.

Dry Ice

An outstanding example of the new competition is found in the new refrigerant, solid carbon dioxide, marketed under the name of "dry ice." A few years ago the dollar spent for refrigeration was invested in natural ice. Later a choice between natural and artificial ice was offered, and more recently the mechanical household refrigerator has claimed its share of the consumer's dollar spent for refrigeration. The latest claimant is the familiar gas carbon dioxide, obtained as a by-product in the manufacture of industrial alcohol or as a principal product by the burning of coke. After purification and liquefaction by the well-known mechanical methods, the liquid gas is cooled by passing around an expansion chamber in which the cooled gas, suddenly released, forms a snow which falls to a compartment in which it is compressed into blocks, looking like sections of great, dense snowballs. The temperature of this material is something around 110 degrees below zero on the fahrenheit scale, and when properly employed it has an efficiency fifteen times that of water ice. While more expensive than water ice, there are many things in its favor, for it permits parcel-post shipments of materials which must be kept very cold, offers obvious advantages in the delivery of specialties like ice cream, since it does away with the cost of collecting the familiar containers, in which such materials are usually delivered, and makes possible express shipments of equal quantities of merchandise at less cost, thanks to savings in the weight of tubs, water ice, and salt, which greatly exceed the weight of the throw-away corrugated-paper carton used with dry ice. Since one ton of this material will keep a refrigerator car sufficiently cold for six days, the time ordinarily lost in reicing is saved, and experiments indicate that much greater cargoes can be shipped where this type of refrigerant is used, than where water ice and salt must be employed. The name "dry ice" is derived from the fact that in performing its work it passes directly from the solid to the gaseous state without an intervening liquid phase.

In whatever field our interest may lie, there can be found evidences of scientific research playing its part in competition. One needs but consider the growing family of special alloys to realize what this has meant in the metal industry, and we find chromium not only in its alloys but as a protective coating a recent factor. One metal or alloy competes with another; ceramic ware holds its own for special applications; and glass is entering many industries as a material for apparatus and equipment for severe duty. Examples might be multiplied, but the purpose of this discussion has, we believe, been fulfilled. Science both requires and deserves increased support, that new discoveries may be made and that new competitions may be both created and met. The establishment of our direct interest in the results is one step toward realizing that support.

A Time-Stretching Camera

Motion pictures are usually made and shown at the rate of sixteen exposures per second. The familiar slow-motion pictures are exposed at the rate of 160 per second and shown at the standard speed. While such pictures have been of some service in the scientific study of motion, their main use has been the amusement found in the grotesque effects they produce.

At the annual meeting of the Society of Automotive Engineers held in Detroit recently, C. Francis Jenkins, producer of the first photographs by radio, described the chronoteine camera with which photographs can be taken at a rate of 3000 exposures per second. Evidently it would be impossible for the film to be stopped and started rapidly enough for this, so the result is obtained by moving the film continuously past a shutter that remains open, the separate views being obtained by matched lenses mounted in a large rotating disk which pass between the shutter and the film.

It is said that enough light is obtained so that the individual views have good photographic qualities. In fact, the exposures are longer than for slow-motion pictures with the standard type of camera because no time is lost while the shutter is closed and it is even possible to continue the exposure of one view until after the exposure of the next view is begun.

One of the greatest difficulties in producing such a camera is the securing of 48 high-speed lenses matched accurately enough for the purpose, but this has been done so well that the pictures are not jumpy.

Pictures can be taken with this camera at various speeds. Several expedients are available for measuring the time, one of them involving a mirror mounted on a tuning fork to produce light flashes on the photographs at the rate of 500 per second. The standard stock super-speed negative film, is used and direct sunlight or its equivalent is required.

Increasing the Durability of United States Paper Currency

The investigation which the Bureau of Standards has been conducting in cooperation with the Bureau of Efficiency and the Bureau of Engraving and Printing with the object of increasing the life of United States paper currency is being actively continued.

One of the most important facts discovered during the past year was that the strength imparted to currency paper by glue sizing is practically all destroyed in the processes used to print the paper. On the other hand, it was found that the basic strength of the paper—that is, the strength produced by the paper fibers—is not impaired by the printing. This has led the Treasury Department to adopt the type of paper developed by the Bureau of Standards as the standard currency paper, because the distinctive feature of this paper is its high fiber strength. Another desirable characteristic of the paper is its lack of grain. It has a folding strength in the two principal directions of over 5000 double folds. A study of commercial papers showed that the Bureau of Standards' paper had no counterpart commercially. In view of this situation, fine-paper manufacturers in general were asked to cooperate in commercial development of the new type of paper. Several concerns conducted paper-making experiments in their mills, following the bureau's paper-making procedure. Commercial papers were produced equal in strength and printing quality to those produced in a semi-commercial way in the Bureau of Standards' mill. This showed that the paper-making procedure developed by the bureau is entirely feasible commercially, and, therefore, that the Treasury Department will not experience difficulty in obtaining the desired type of paper.

Additional problems in the paper-manufacturing processes are being studied in the bureau's mill. Results so far obtained in investigation of the relative merits of cotton and linen fibers indicate that a part of the expensive linen fibers can be replaced by the cheaper cotton fibers without material injury to the quality of the paper. Also it is believed that caustic soda is preferable to lime in cooking the paper-making rags, in respect to both strength of the paper and its printing quality. Additional glue surface-sizing data obtained indicate that formaldehyde is preferable in many respects as a preservative for the paper glue-sizing solution, to the more commonly used alum. It is estimated that these investigations have resulted so far in increasing the life of the paper currency over 40 per cent.

The Rowland Ruling Machine

Details Regarding the Mechanism and Working of This Historic and Interesting Precision Dividing Engine Devised for Engraving the Lines of Diffraction Gratings

DR. HENRY AUGUSTUS ROWLAND is still remembered as a great physicist after more than a quarter of a century. When he died on April 16, 1901, he had for twenty-five years been professor of physics and director of the physical laboratory at The Johns Hopkins University, and he left behind him a vast number of outstanding achievements in pure science which have been of great value in practical electrical and mechanical engineering.

Professor Rowland—as he was generally called during his lifetime—gave much attention in his later years to the theory of light, and in this connection he became deeply interested in the problem of resolving the lines of the spectrum. He found that the best instrument for this purpose was the diffraction grating. A diffraction grating is a mirror—usually of speculum metal—upon the surface of which fine, closely spaced lines have been engraved. The best of the early diffraction gratings were—strange to say—made by an amateur astronomer, Lewis M. Rutherfurd, of New York City. Rutherfurd, who was a lawyer by profession, began his work upon diffraction gratings about 1870, and eventually he developed a machine which would rule them—though the best of them were small in size and rather uneven in spacing. In spite of their shortcomings some of the finest mechanics in France, Germany, and the United States had been unable to equal Rutherfurd's gratings. This was the situation about 1880, when Professor Rowland tackled the problem.

Professor Rowland was fortunate in being able to enlist the skill of the master mechanic Theodore Schneider, who was the instrument maker at The Johns Hopkins University for twenty-five years. They made use of the University physical laboratory in the carrying out of their project.

The Problem of Ruling Gratings

Although the wave theory of light, upon which the fundamental design of diffraction gratings is based, is most refined and complicated, the problem of making the gratings is itself purely a mechanical one—comparable to the dividing of a precision scale for measuring purposes. As a matter of fact, Professor Rowland actually did apply his apparatus to the dividing of metric scales.

The grating problem is to engrave upon the surface of very slightly concave, optically correct mirrors of speculum metal, fine lines which must be uniform in quality, absolutely straight and parallel, and exactly spaced an almost infinitesimal distance apart. It may be mentioned here that Rutherfurd's best gratings were about $1^3/_4$ in. square and carried about 30,000 lines. His difficulty in producing larger gratings was primarily one of holding uniform spacing throughout the long period required to carry out the engraving process. Such a slight disturbance as a fluctuation in temperature of a few degrees while the engraving is in progress is sufficient to affect the spacing and thereby ruin the grating.

Professor Rowland designed a machine which was comparatively simple, yet which after Mr. Schneider had completed it proved to be in every sense of the word a "super-dividing engine." The vital detail of the machine was a lead screw of extreme accuracy, the making of which was described by Professor Rowland in the ninth edition of the Encyclopedia Britannica under the title of "Screw." This article was, apparently, the only published material relating to the building of the dividing engine which was written by Professor Rowland himself.

In this description he gives credit to Professor William A Rogers of Harvard for devising a method of cutting in a lathe a precision screw as much as a yard long with errors not exceeding 0.001 in. in the lead. It will be recalled that Professor Rogers and George M. Bond were about 1880 engaged at Hartford, Conn., in the building of the famous Rogers-Bond comparator. This instrument was briefly described in the July, 1927, issue of MECHANICAL ENGINEERING.

Lapping the Lead Screw

With such a screw as this to start with Professor Rowland devised a grinding process which utilized a peculiar adjustable nut charged with emery and oil. To finish a precision screw 12 in. long, for instance, he employed a grinding nut 11 in. long, made of bessemer steel in four segments, which were drawn together by opposed sleeves fitted to the double cone-shaped body of the nut assembly. The original thread was of sharp V-shape, slightly sharper than 60 deg., and was of twenty threads to the inch.

The grinding—or more properly, the lapping—of the thread by this nut was done in a lathe and under water held to within one degree of constant temperature. The weight of the nut was counterbalanced by weights acting upon it through a cord carried over a pulley. Beginning with 20-in. strokes, using emery and oil, and toward the end employing 10-in. strokes and using silica powder or rouge, the lapping process was continued for two weeks, the nut being turned end for end every ten minutes. This long-drawn-out process resulted in a screw of rounded thread section from which were eliminated to a high degree errors in run, and drunkenness, crookedness, and irregularity in size. Such a screw was next cut to the desired length, centered in a lathe by the use of a microscope, and its bearings carefully turned to size.

Three of these dividing engines were built under Professor Rowland's direction. They were capable respectively of ruling 14,438, 15,020, and 20,000 lines to the inch. All of them had lead screws of twenty threads to the inch, the difference in spacing being achieved by the number of teeth in the ratchet wheels by means of which the screws were revolved.

A general idea of the size and character of these machines is given by Fig. 1 accompanying this article. This illustration was made from an old photograph showing Professor Rowland examining his creation. Details are revealed by the drawings, Figs. 2 and 3, which were made from one of the original machines.

Although relatively small in size and simple in its basic principles, the Rowland ruling machine contains no less than sixty important details. Some of these—as in the case of the lead screw already mentioned—required great ingenuity in their conception and infinite patience and mechanical skill in their construction and assembly.

General Characteristics of the Machine

The machine can be compared structurally to a simple reciprocating steam engine. It has a flywheel, a two-bearing crankshaft, a connecting rod, a crosshead, and a slide which corresponds in location to a piston. The crankshaft, or main shaft, just mentioned carries in the following order the flywheel (which is also the driving wheel); a pair of disk cams fastened side by side between the flywheel and the first bearing, the one

next to the flywheel actuating the main lever of the feed mechanism while the other actuates a supplementary lever pivoted to the main lever and which engages and disengages the pawl itself at the proper times; a third disk cam near the left-hand bearing which actuates the mechanism for "backing off" the diamond engraving tool during the return stroke of the ruling head; and lastly an adjustable-throw crank which serves to reciprocate the ruling head carrying the diamond.

The base of the machine is a scientifically designed box frame of cast iron, carried on legs of steel rod of such length as to allow the placing of the machine upon a bench or table. At the front end of the frame is mounted the driving mechanism just mentioned, while at the rear is mounted the working mechanism which is about to be described.

This working mechanism has as its foundation two accurately made tracks or ways of the double inverted V-type. The lower set of these is parallel to the driving shaft, while the upper set is above and at right angles, the two axes crossing at their centers. The lower ways carry the work table or plate carriage, and have mounted between them the lead screw. This is supported in two bearings at the ends of the ways, the one at the left (when facing the rear of the machine) having a supplementary thrust bearing which in the original design consisted of adjustable hardened steel plugs—one screwed into the lead screw and one into the boss on the frame.

The ways are hardened steel strips set into the cast-iron frame, and the cast-iron plate carriage runs directly upon these steel ways. The nut which drives the plate carriage from the lead screw is a very important element of the machine. Both in its construction and in its method of transmitting motion to the carriage it is unique.

Design of Lead-Screw Nut

The nut is made of wrought iron and is split lengthwise in two halves. Both halves are filled with lignum vitae plugs which stand above the surface on the inside. The thread is cut upon the ends of these plugs instead of upon the metal. These two halves are held in contact with the lead screw by springs within loose-fitting collars, so that they are to a certain extent free from each other and can move independently within the possible limit of error of the thread. A thrust ring is attached to the plate carriage by pins about which it is free to swing on a vertical axis. Studs set in the ends of each half of the nut bear upon the sides of the swivel ring 180 deg. apart and 90 deg. from the turning axis of the ring. The motion of the nut is transmitted to the carriage through this connection, which allows each half of the nut to do its share of the feeding and compensates largely for any lack of parallelism between screws and ways or any eccentricity in the screw mounting. The residual periodic error of this feeding mechanism is corrected by a mechanism which will be described later on.

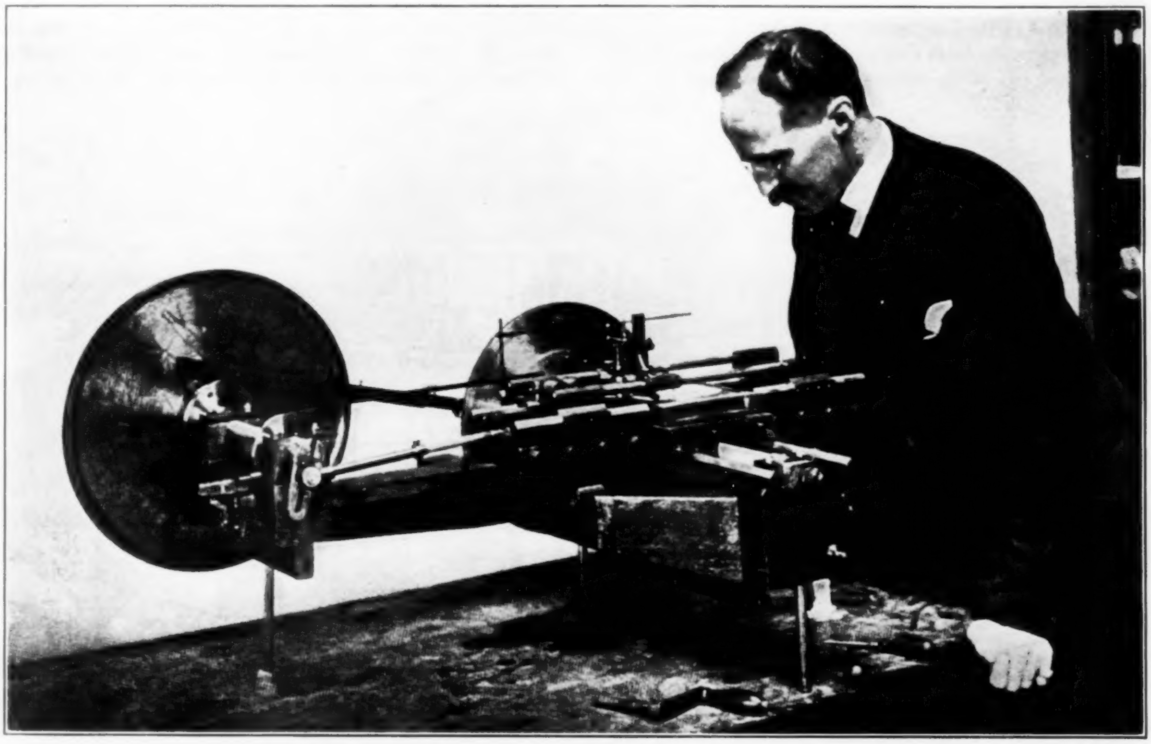


Fig. 1 An Early Photograph Showing Professor Rowland Examining His Ruling Machine

The upper ways, which guide the ruling head, have a gap at the middle to allow for the passage of the plate carriage. There are two sets of shoes carrying the head itself, one set bearing upon one end of the divided ways and the other set upon the other end. The two sets of shoes are connected together, and the gap bridged over, by a pair of parallel steel rods. The support for the diamond mechanism is in the nature of a clamp which is adjustable along these rods and carries an auxiliary slide which is adjustable vertically, so that the diamond can be properly located with respect to the work. The shoes which carry this assembly are lined with boxwood and bear upon the top and sides of steel ways.

The crosshead is not integral with this mechanism, but is a supplementary slide carried in grooves in the frame below the forward section of the ways carrying the ruling head. To avoid transmitting possible inequalities of travel from the crosshead to the ruling head, the connection between these two elements is

through the medium of a flexible link, in the shape of a flat spring.

The Spacing Mechanism

The lead screw carries at its right-hand end a large steel disk which is mounted upon a cast-iron center. This disk, called the ratchet head, has fine and very accurately spaced teeth cut upon its periphery. The accuracy of spacing of these teeth is fully as important as the accuracy of the lead screw. They were cut in a machine used for dividing circles for astronomical instruments.

The lever carrying the feed-pawl mechanism is pivoted in an outboard bearing located close to the end of the lead screw at the right, and is in line with its axis. The main lever is held down by its own weight so that its free end is always in contact with its operating cam on the main shaft. The pawl is fastened across the down-pointed end of the shorter arm of a bellcrank which is pivoted to the inner side of the main lever close to the periphery of the ratchet head.

During the upstroke of the main lever the supplementary lever bears against an adjusting screw in the long arm of the bellcrank and holds the pawl out of engagement with the ratchet teeth. This supplementary lever is pivoted at the center of the main lever and is actuated by a cam similar to and located beside the main-lever cam on the main shaft. These two cams are interchangeable with others of different throws, and upon their throw depends the number of ratchet teeth passed over by the pawl in the upstroke and therefore the feed per revolution given to the plate carriage.

When the main lever reaches its high point the auxiliary lever continues to rise, and this releases the bellcrank and allows the pawl to engage the teeth of the ratchet head during the downstroke. Positive engagement of the pawl is assured by a weight hung from the long arm of the bellcrank. The depth to which the pawl enters between the teeth of the ratchet head is governed by an adjusting screw in the bellcrank which contacts with a stop on the pawl lever. By this action the lead screw is turned slightly and the spacing is accomplished.

The Corrector Mechanism

It was found necessary to introduce into the machines an additional refinement in connection with this spacing operation. This so-called corrector mechanism was designed to compensate for the residual periodic error which persisted in spite of the utmost refinements in the construction of the machine. It consists of a frame hung below the rear of the machine by a crank and links so that it may have a forward and backward motion when the shaft on which the crank is clamped is rocked by a lever actuated by an adjustable cam on the face of the ratchet head.

At the front end of this swinging frame is a trough extending across the machine below the lead screw. To each half of the lead-screw nut there is attached a wing or lever the ends of which are carried in this trough and, while free to travel across the machine, are held by it from turning. By a rather complicated process of examination of superimposed gratings ruled upon glass plates and the measurement of the comparative amplitude of wavy dark lines which appear and the distance apart of two lines, the amount of the periodic error can be determined. Its phase has to be found by a trial-and-error method of setting the corrector cam.

When this cam is properly located and properly timed it gives to the nut a slight backward and forward turning movement upon the screw, which effectively neutralizes the periodic errors in the screw and its mounting.

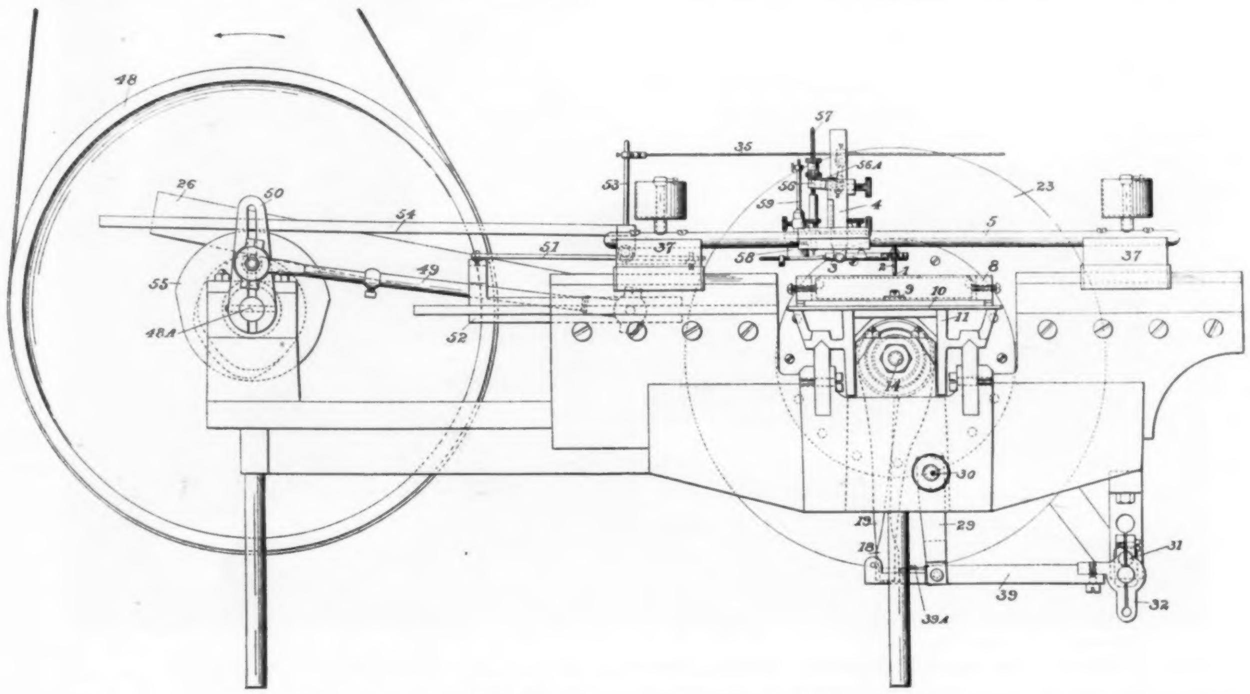


Fig. 2 Left-Side Elevation Showing Machine in Ruling Position

The Control of the Diamond Engraving Tool

The diamond engraving tool is set in the end of a short rod by the use of solder. This diamond holder is in turn adjustably held in a horizontal bar, at its center and below the adjustable support on the tie rods. The arm of this lever to which the diamond holder is fastened is heavier than the other arm, and the diamond contacts with the work during the engraving stroke on account of this unbalanced weight. To regulate the cutting pressure a small counterweight is threaded upon the opposite end of the rod.

During the non-cutting or return stroke of the machine—at which time the feeding of the work table occurs—the diamond is lifted and held clear of the work by a system of levers actuated by a disk cam located on the main shaft near its left-hand bearing. The main lever of this system is a long bar lying normally parallel to the bed of the machine, with its free end resting upon the operating cam and coupled to the crosshead by a pivot through a short "L" arm at the opposite end. Its normally parallel position allows this lever to slide back and forth on its cam through the motion of the diamond head without introducing any undesirable extra oscillations due to angular displacement. In the top of this long lever, directly over its pivot, is set an upright rod. On this rod is an adjustable coupling to which is pivoted a still smaller rod extending horizontally and adjustably connected with a bellcrank mounted in the upper part of the frame of the mechanism carrying the diamond.

The horizontal arm of this bellcrank is in the form of a fork. This fork straddles an upright diamond lift rod and contacts with an adjustable stop to lift this weighted rod when the arm of the bellcrank rises. This rod lifts the diamond by its weight bearing down upon the lighter arm of the horizontal lever which carries the diamond. Set parallel to the diamond lift rod is a dashpot arrangement which, by means of a reservoir of oil, dampens any vibrations of the diamond mechanism during the working stroke and also causes it to descend gradually to its cutting position. The dashpot itself is fixed to the frame of the ruling head, while the dashers are fastened to an adjustable vertical rod which is parallel to, and affixed to, the diamond lift rod.

The final detail of the Rowland ruling machine is the driving mechanism of the ruling head, some features of which have already been mentioned. Its adjustable-throw crank is of the slotted variety and is pinned to the end of the drive shaft. In the slot is an adjustable crankpin. The throw of the crank is regulated by setting this pin in or out from the center, its location depending upon the size of the grating which is to be ruled. The connecting rod is made up of a telescoping rod and tube which may be clamped at various lengths, thereby keeping the crosshead within the proper limits of its bearings regardless of the throw of the crank.

THE OPERATING CYCLE

The cycle of operations of the Rowland ruling machine during one revolution of its main shaft is as follows: Starting with the diamond resting upon the mirror surface at the beginning of a line it is drawn forward—that is, toward the main shaft or front end of the machine—by the action of the crank. Thus one line is ruled. Then when the crank is about to pass its center and the stroke to reverse, the cam controlling the diamond-lifting mechanism does its duty and the diamond is raised and held off the surface of the mirror. The return stroke then occurs, and coincidentally the plate carriage advances the minute amount which represents the spacing of the rulings. This "indexing" is accomplished by the action of the cams operating the main and auxiliary pawl levers. During the working stroke these levers operate to draw the pawl out of contact with the teeth of the ratchet head and lift it to a predetermined height, carrying it over one or more teeth, depending upon the width of the spacing. Then, at the beginning of the return stroke, one of the cams operates to engage the pawl with a tooth of the ratchet head, thereby causing the head and the lead screw to revolve through a small but very definite angle during the down stroke of the pawl levers. This causes the nut to advance toward the ratchet head, which in turn pushes the plate carriage in the same direction a distance of the spacing between rulings. It is during

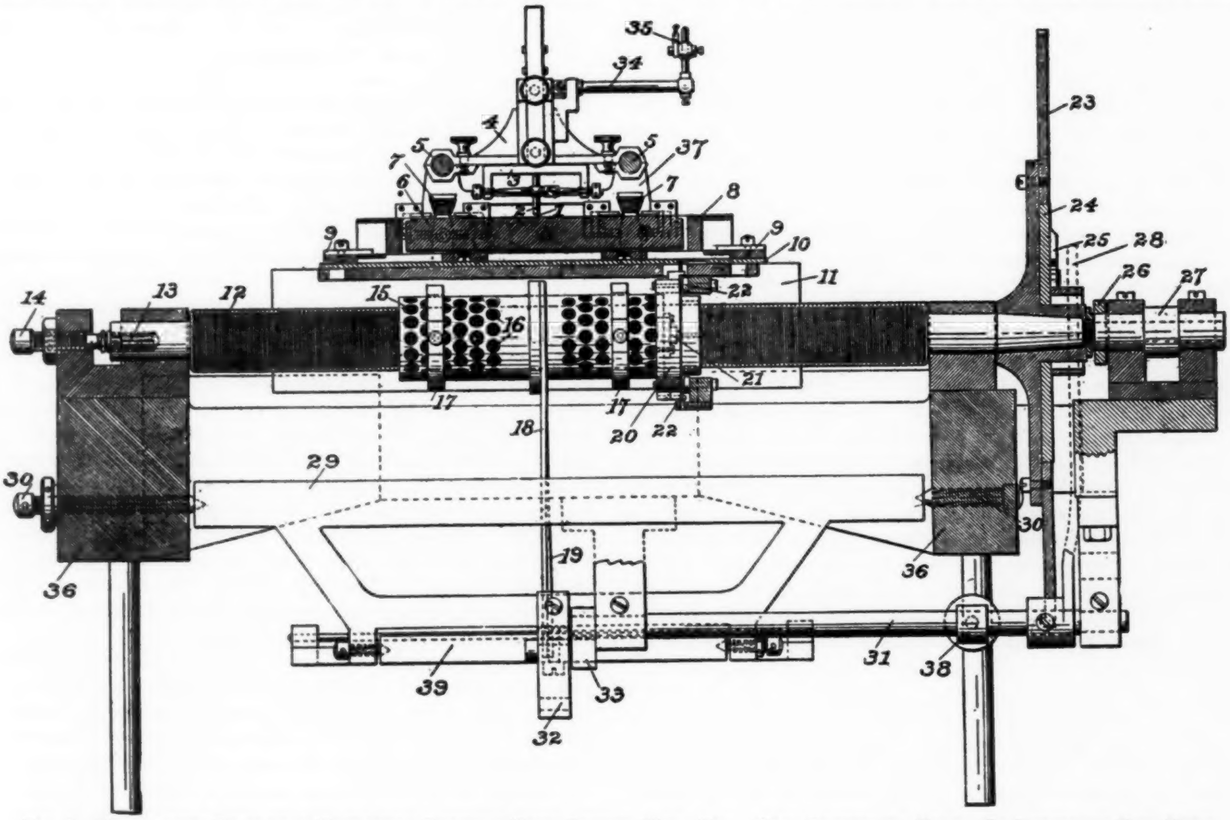


FIG. 3 TRANSVERSE SECTIONAL ELEVATION SHOWING FEED SCREW, NUT, ETC. THE CORRECTOR FRAME IS SHOWN IN END VIEW

this indexing part of the cycle that the slight turning movement is imparted to the nut by the corrector mechanism in order to compensate for the periodic errors.

At the end of the cycle the diamond lowers into contact with the mirror in a new position—ready to rule the next line. Through the influence of the oil-filled dashpot this lowering of the diamond is gradual instead of being a sudden drop. The machine will not operate satisfactorily at a speed exceeding twenty strokes per minute. The time required for ruling gratings of various sizes and grades of fineness ranges from two and one-half to seven days of continuous operation.

A Machine with Sensitive Feelings

During the long period of the ruling operation there can be no stopping and starting, no variation of speed, no variation in the temperature of the room, and as a matter of fact a person cannot approach the machine without danger of introducing an area of inequality into the grating through the effect of bodily heat. Fluctuations in the flow of lubricating oil to the moving parts are inclined to introduce variations, and the slight wear which takes place in the mechanism during the ruling of a grating shows its effect in the case of large areas.

It is self-evident that the carrying out of such a delicate mechanical process as this demands infinite patience and a high degree of skill. For this reason it was freely predicted, when Professor Rowland and Theodore Schneider died within a few weeks of each other, that the art of ruling diffraction gratings would be found to be definitely lost.

This did not prove to be the case, however, and between 1902 and 1913 diffraction gratings of the highest quality were ruled on the Rowland machines by Dr. J. A. Anderson, now of the Mt. Wilson Observatory in California, where he has since built a ruling machine of his own. After a ten-year period of inactivity on the part of the Rowland ruling machines, Dr. R. W. Wood and Dr. C. R. Canfield became interested in the possibilities of the apparatus, and since 1923 many gratings of high quality have been produced by Dr. Canfield.

Modern Improvements Introduced

Both the technique of making the mirrors and the design of the ruling machines have been somewhat modified and improved of late. Of the three Rowland machines two are now in active operation in a constant-temperature vault in the basement of the Electrical and Mechanical Engineering Building at The Johns Hopkins University. The temperature is maintained by a gas heater with thermostat control.

The original water-motor drives of the machines have been replaced by oversize direct-current electric motors. The belts from the motors, instead of driving directly to the flywheels as used to be the case, now pass around similar auxiliary wheels set beside the flywheels and upon the same axes, but connected with the flywheels only by light coil springs in tension. This flexible connection insures uniform torque and eliminates a periodic error which formerly appeared on account of the deflection in the frames of the machines each time the lapped and cemented joint in the belt passed over the flywheel. Ruby thrust blocks have been substituted for the hardened steel thrust bearings originally used on the lead screws. Cut diamonds, which are accurately ground in a special machine to the proper engraving shape, are now used instead of the uncertain natural crystals employed in the old days.

In closing this article advantage is taken of the opportunity to give credit to Prof. A. G. Christie, head of the Department of Mechanical Engineering at The Johns Hopkins University, for bringing these historic and interesting precision dividing engines to the attention of the A.S.M.E. Through Professor Christie appointments were arranged with Dr. Wood and Dr. Canfield to see the machines in operation and to gather at first hand the material for the article.

The illustrations and some of the facts have been taken from the memorial volume entitled "The Physical Papers of Henry Augustus Rowland," permission being given by Dr. Ames and Mr. Dittus on behalf of the authors and publishers. This very complete work was compiled by a committee representing the University immediately after Professor Rowland died, and was published in 1902 by The Johns Hopkins University Press.

Cohesion

MANY engineers think of the term "strength" as equivalent to "tensile strength" as indicated by a simple tensile test, but it is easy to show that while such a test affords valuable and necessary data concerning the properties of materials, it is no true measure of "strength." The behavior of metals under fatigue, shock, prolonged loading and other sets of conditions encountered in practice clearly shows that the material of highest tensile strength is not by any means the "strongest" or best for all purposes. We cannot as yet isolate and test separately the various factors upon which strength in service depends; on the other hand, tests designed in direct imitation of service conditions can rarely be made sufficiently perfect scale models to yield reliable results. Only when we know more about the inner mechanism of cohesion shall we be in a position to attach proper relative weight to the various more or less complex properties which we can test in our laboratories and workshops—and it is only when we can do this that we shall be able properly to evaluate the indications of our testing machines. Indeed, it is quite possible that when this deeper knowledge is available, we may abandon or seriously modify our present methods of mechanical testing and substitute for them something far more searching and direct in its indications.

When we know why and how cohesion is developed to such widely varying degrees in different materials, we shall have the key not only to the selection of those best suited for a given purpose, but to the production of new combinations of matter—new, perhaps, rather as to the state into which the material is brought than as to its composition—capable of giving the engineer of the future materials far beyond the ken of our metallurgists of today. If the full cohesive strength of solid matter could be rendered available in practicable materials, degrees of strength far greater than those with which we are familiar today should be realized. Already a physicist has produced bits of rod of fused silica which can develop a tensile strength of over 200 tons per sq. in., and yet from the point of view of inter-atomic cohesion silica should be one of the weaker materials. As yet we do not know exactly why this remarkable degree of strength is attained, but as we learn to understand these things so our power of producing correspondingly startling results will also increase, and laboratory marvels will become working materials. It may take a long time for these developments to occur and to reach the practical stage, but progress is sometimes startlingly rapid. We have seen, for example, how in a few decades the laboratory "oscillator" of Hertz and of Lodge has grown into the "super wireless" station radiating hundreds of kilowatts from its mile-long antennae and sending its signals several times around the earth. We are too apt to think that since so much has been attained in regard to materials little more remains to be achieved. A realization of how far we are as yet from understanding the fundamental phenomena of cohesion must give us pause in any such line of thought.—*The Metallurgist* (supplement to *The Engineer*), Dec. 30, 1927, p. 177–178.

The Modern Fire Engine

AT ONE of the sessions of the 1927 Annual Meeting of the A.S.M.E., Karl W. Stinson, assistant professor of automotive engineering at The Ohio State University, Columbus, Ohio, presented a paper[1] dealing with the modern fire engine. Professor Stinson began by giving a historical outline of the development of the fire engine and then stated the general requirements of the modern type and described briefly the typical gasoline fire engine. He next considered the types of pumps and described the principal features of piston, rotary, and centrifugal pumps as applied to fire engines. In conclusion he compared gasoline and steam fire engines, and stressed the need for a standard specification for fire apparatus.

A. Hollander[2] and W. L. Forward[3] submitted a written discussion of the paper, in which they said that with the increasingly general application of centrifugal pumps in the last fifteen years in every field of pumping, the question naturally arose why fire engine pumps did not follow this general trend, and why rotary pumps should be predominant in a field where stationary pump practice as a rule would turn to centrifugals. The answers to these questions would automatically indicate the probable future trend.

As a first point of comparison the requirements of operating conditions might be considered, namely, capacity and pressure at the available speeds. In reference to the speed, due to the fact that the same engine was used for traction effort as was used to drive the pump, gears were necessarily introduced between the engine and pump so that the most desirable pump speed might be selected.

In reference to head and capacity the requirements, as the author stated, were as follows: 120 lb. pumping pressure at the rated capacity, 200 lb. pumping pressure at one-half, and 250 lb. at one-third of the rated capacity. Refiguring these data in percentages, if the capacity, pressure, and water horsepower were given as 100 per cent at the rated point of 120 lb., then there would be 50 per cent capacity, 166 per cent pressure, and 87 per cent water horsepower at 200 lb. pressure, and 33.3 per cent capacity, 208 per cent pressure, and 70 per cent water horsepower at 250 lb. pressure.

To accomplish these ratings, the most satisfactory and logical operation would be to run the pump at constant speed. This was impossible with a straight multi-stage centrifugal pump, and still more pronouncedly so with rotary pumps. A rotary or plain displacement pump running at constant speed would require that the engine develop 87 per cent of its power at one-half speed and 70 per cent of its power at one-third speed, a self-evident impossibility.

To attain these conditions even approximately with a straight multi-stage centrifugal, a very steep head-capacity curve was required, and even so, at the high pressures the speed had to be increased from 15 to 30 per cent. The fact that the water horsepower was maximum at the rated point of 120 lb. while the engine had to run with the lowest speed, showed that the two machines did not synchronize as far as power requirements were concerned. Furthermore, a plain straight multi-stage centrifugal pump would have materially reduced efficiency at one-half and one-third capacities, especially if these low capacities had to be obtained at increased pump speeds. As a result the power requirements of a straight multi-stage centrifugal pump were 15 to 25 per cent higher than if the centrifugal could work at a condition nearer to its point of best efficiency.

In order to synchronize the power requirement of the pump and the power output of the engine and to run at a constant speed and work close to the maximum efficiency point of the pump for all conditions, one naturally turned to the solution which had been adopted in stationary practice, namely, the use of two pumps operated in parallel for the high-capacity and in series for the low-rated-capacity requirements. Two pumps working in parallel, each delivering one-half of the total output at 120 lb., would automatically deliver one-half of the total capacity at 240 lb., and at the same time be operated at maximum efficiency. This 240-lb. pressure was between the required one-half and one-third capacity pressure of the Underwriters'; or stated in another way, such a pumping unit without speed change at one-half capacity would give 20 per cent higher pressure than the Underwriters' specifications.

Requirements for a Series-Parallel Multi-Stage Pump to Adapt It to an Auto Fire-Engine Chassis

In order that such a series-parallel multi-stage centrifugal pump be adaptable to the auto fire-engine chassis, it must fulfil the following requirements.

1 The pumps must be constructed in one pump housing to form a single self-contained unit, thereby reducing the space requirement to a minimum.

2 The change-over from parallel to series operation or reverse must be accomplished by means of an extremely simple and reliable mechanism, preferably incorporated within the pump housing.

3 Complicated or tortuous waterways or passages, such as guide vanes, etc., should be eliminated.

4 It must be efficient with the maximum efficiency close to the rated-capacity requirement or at a greater capacity than the rated Underwriters' requirement, if desirable.

5 It should be controlled by a pressure governor which would limit the maximum pressure to any predetermined point, made attainable by means of a simple and easy adjustment within reach of the operator from his one position or station at the control panel. Furthermore, the governor should include in its mechanism on the control panel an auxiliary hand control, which should operate as such when the governor was cut out, and should limit the maximum engine throttle within which the governor should operate when cut in.

6 Following modern pump construction, the multi-stage series-parallel unit should be so designed as to permit inspection or repair of the working elements without disconnecting suction or discharge fittings and with the minimum disturbance to the assembled chassis parts and without the removal of the unit from the chassis.

The author had very aptly described such a series-parallel multi-stage centrifugal pump in his paper, and briefly summarized its advantages, all of which had been accomplished by conforming strictly to the six above-enumerated basic principles.

The following discussion referred to series-parallel centrifugal pumps which had been built along these lines.

Going back to the first point of comparison between the cen-

[1] Published in Mechanical Engineering, vol. 49, no. 12, December, 1927, pp. 1288–1292.

[2] Chief Engineer, Byron Jackson Pump Mfg. Co., Berkeley, Calif. Mem. A.S.M.E.

[3] Asst. Chief Engineer, Byron Jackson Pump Mfg. Co., Berkeley, Calif.

trifugal and rotary covering the capacity and pressure requirements at the available speeds, it could be broadly stated as proved above that the centrifugal was more adaptable to meet them.

The second point of comparison was the drive. The centrifugal pump could be thrown in gear from the driver's seat and did not require shifting during operation. The rotary with two or three speeds must have shifting devices requiring clutch manipulation, a recognized hazard bringing out quite clearly the superiority of the centrifugal application.

As a third point of comparison the centrifugal pump utilized the full flowing pressure of the hydrant, while the rotary used only a part of it.

As a fourth point and a direct consequence of the third, with centrifugals, pressures and capacities might be attained way above the Underwriters' requirements, without change of speed and with full utilization of hydrant pressure. As an example, the 1000-gal. pumper, briefly referred to in the paper, with 65 lb. hydrant pressure gave 674 gal. per min. against 300 lb. discharge pressure, and 1975 gal. per min. against 120 lb. discharge pressure, at a constant engine speed. Such large capacities were impossible with rotaries, even with speed change.

As a fifth point of comparison, additional inherent advantages of the centrifugal pumps might be mentioned, such as no surfaces running to very close clearance, simplicity of construction, ease of assembling and dismantling, and also low bearing pressures.

As a sixth point of comparison, the necessity of relief and churn valves on the rotary and the human element involved for even partially satisfactory results, and the total elimination of any such valves on the centrifugal was another vital point of superiority in the latter's favor.

As a seventh point, the lack of pulsation without the use of air chambers should be emphasized, assuring long life to the hose and eliminating the necessity of using sacks or any kind of gear to avoid wear due to chafing.

The eighth point of comparison, the former advantage of rotaries that they are self-priming when new and not too much worn, was offset by the introduction of the Nash primer. This primer operated on a hydraulic principle without metal contact and was constantly running and ready to prime the centrifugals at the start or at any time during operation without the necessity of any clutch or shifting device.

The ninth point was a comparison of efficiency. Centrifugals were 70 per cent efficient or better for the 750- and 1000-gal. units, and about 68 to 70 for the 500-gal. units. The rotaries had a slight margin when new, but did not maintain their efficiencies like centrifugals over long periods of time, because they depended on close clearances, which rapidly increased in service.

As a tenth point, with the rotary pumps as at present constructed there might be a margin in price in their favor, which, however, in percentage of the total price of the apparatus was insignificant.

To summarize: the series-parallel centrifugal pump which combined the inherent advantages of the plain multi-stage type with the special advantages of a pump built for automobile fire apparatus was superior to rotary or displacement pumps in every respect.

The answer to the original question of why the centrifugal had not yet been generally adopted was that the special centrifugal pump as described above had only recently been put on the market, and therefore manufacturers of other types of pumps, especially of rotaries, had not been forced to revise or improve their product, which had remained practically unchanged for some ten years past.

The standard practice of cities requiring pumping equipment for water works, fire service, or fire boats was to consider only centrifugal pumps. The fire-engine pump apparatus of the future would certainly follow the same trend.

The writers heartily agreed with the author's suggestion that standardization was very desirable and would be instrumental in bringing about improvements and a lower price at the same time.

Donald A. Hampson,[4] commenting on the author's statement that the politician and not the engineer was the person who decided what would best protect our homes and buildings from fire, wrote that until that condition was remedied, we should continue to pay 20 to 25 per cent more for fire engines than they ought to cost. The modern fire engine was probably the most complicated piece of machinery that traveled on four wheels, yet we blithely permitted amateur committees to write specifications for its manufacture and politicians to run the sales costs into five figures! It was a practice without parallel, even in sketchily run municipal affairs.

The modern fire engine was an assembly that was mechanical from beginning to end. Design, materials, operation were essentially the product of research and up-to-date manufacturing. Why should the layman attempt to interfere with a matter so technical? The trained engineer was the one person who was fitted to pass upon fire-engine selection and sales—he knew methods, materials, design; to him, standardization was a watchword. Were the ridiculous insistence of elective officers and politicians to cease to exist, costs would be lowered.

Although the engineer was being recognized more and more in public affairs, his peculiar fitness to deal with matters of fire protection in his own community was quite overlooked. Members of the Society were in a position to be of great service in connection with fire engines. There was the matter of selection, dealing with types and capacities, plotted against local building and water-supply conditions. Machines were usually required to pass a test such as specified by the National Board of Fire Underwriters; where engineers of the Board were not asked to conduct such acceptance tests, the tests were likely to be little more than a formality unless a competent engineer was engaged to report on them. And a machine in service required something more than garage-man attention to be of value to a community—it should pass periodic tests to show a maintained efficiency.

A number of cases where members of the A.S.M.E. had been called upon by municipal executives had come to the writer's attention, and, without exception, the advice of these men had been the means of saving money and securing reliability.

Ericsson's Early Work on Fire Engines

In the oral discussion which followed, H. F. J. Porter,[5] referring to the author's statement that the first steam fire engine was built in 1830, quoted from Col. William C. Church's "Life of John Ericsson" statements regarding Captain Ericsson's introduction of steam fire engines in England and the Continent as early as 1828.

The Science Museum, South Kensington, London, had in its collection a colored drawing, scale 1:12, of Braithwaite and Ericsson's steam fire engine of 1830, and regarding this the Director of that Museum in a communication dated August 28, 1922, said:

"Captain John Ericsson, a young Swedish engineer, came to London in 1826 (?) and went into partnership with John Braithwaite, Civil Engineer, of London. Following is a copy of a memorandum made by Captain Ericsson himself and published in *The Engineer* of December 31, 1875:

[4] M.E., Morgan & Wilcox Co., Middletown, N. Y. Mem. A.S.M.E.

[5] Secretary, National Museum of Engineering and Industry, New York, N. Y. Mem. A.S.M.E.

1828: Designed a steam fire engine, mounted on a rude carriage for experimental purposes. The working cylinder was 12 in. in diameter, placed vertically, a double acting force pump of $8^1/_2$ in. diameter being placed on each side operated by means of a crosshead attached to the piston rod of the steam cylinder. The machine was thoroughly tested by throwing jets of water varying from 1 in. to $1^1/_4$ in. in diameter, to the top of the chimneys of certain breweries. The boiler was cylindrical, and placed vertically, the furnace, slightly conical, being also vertical. The heated air and products of combustion passed off through a helical flue, terminating at the top of the boiler. The air for supporting the combustion was supplied by a reciprocating blowing machine worked by the engine when in operation. The trials proved so satisfactory that Mr. Braithwaite, who built this first steam fire engine, decided to make another, to be mounted on a light frame suspended on springs suitable to run on pavement for practical purposes. I accordingly at once designed the second steam fire engine. The work was pushed vigorously, the machine proving a perfect success on first trial. Shortly after its completion the memorable conflagration at the Argyll Rooms offered a chance of testing the engine in actual practice. An account of the performance of this new fire extinguisher will be found in the *Mechanics' Magazine* of February 13, 1830. Having thus originated, elaborated and perfected the new system, I claim to be the father of steam fire engines, cheerfully admitting, however, that, but for the confidence and liberality of my friend and patron, John Braithwaite, it would not have been in my power to carry my plan into practice. It is proper to mention that I designed two other steam fire engines—one for the Liverpool docks and one for the Prussian Government.

"Ericsson and Braithwaite's first machine weighed forty-five hundred-weight, indicated 10 hp., and had two horizontal cylinders and pumps. Each steam and water piston was attached to one rod, and the stroke was terminated by an elastic cushion of steam. This engine threw from 112 to 150 gal. per min., to a height of 90 ft., and it repeatedly proved itself able to work continuously during long periods without breaking down.

"Supt. Braidwood, of the London Fire Brigade, was, at that time, opposed to the use of steam fire engines, and Ericsson and Braithwaite's first engine of this kind was run to London fires gratuitously for some time without having any official connection with the London Fire Brigade. Supt. Braidwood, however, altered his views in regard to steam fire engines some time before his death.

"Ericsson and Braithwaite's second steam fire engine was finished in the year 1831. It was smaller than the first engine but threw 168 gal. of water per min. through a one-inch nozzle to a height of 109 ft. The steam cylinder was 7 in. diameter, the pump $6^1/_2$ in. diameter by 18 in. stroke. The engine worked at a steam pressure of 50 lb. per sq. in.

"The third engine was built for the Liverpool Docks and was arranged with gearing to reduce the speed of the pump pistons. The engine had two cylinders and two pumps placed horizontally.

"The fourth steam fire engine turned out by Ericsson and Braithwaite was manufactured in the year 1832 for the Prussian Government. This machine weighed four tons. It had two cylinders, each 12 in. diameter, and two pumps, each $10^1/_2$ in. diameter, a stroke of 14 in., and was intended to work at a slow speed about 18 strokes per minute. At this speed the engine threw 304 gal. per min., and a vertical height of 120 ft. was reached through a $1^1/_4$-in. nozzle."

With regard to the author's comment on air chambers, Prof. R. W. Angus[6] asked if he had ever seen one large enough to stop the pulsation. Every one that Professor Angus had seen had a pulsation which was bad. The rotary-gear type of pump was desirable for pumping from a well, as the pump could prime itself. He had seen some of these pumps opened, in which the teeth had been very badly worn, nevertheless they seemed to have operated with about the same efficiency as when first made. He wondered whether the author could give any information regarding the effect of packing in the gear teeth on the life and efficiency of the ordinary gear pump.

Prof. W. T. Magruder,[7] chairman of the session, said that forty or fifty years ago in certain villages of New York State the volunteer fire departments were very influential. They not only ran the elections and decided who should be the president of the village, but their dance was the social event of the year. The painting of the fire engines red rather than a more modest color was good advertising for the organizations. In those days it was not at all uncommon to spend $1500 in the painting of a locomotive which would otherwise cost from $8000 to $10,000. It was decided forty years ago and more that gaudiness of painting of steam fire engines and locomotives did not add to their efficiency. One of the objects of the author's paper seemed to him to be the idea of causing motor fire engines to be better standardized and made a piece of engineering equipment, rather than a political tool, and that it should be the duty of the Society to cooperate with others and with the United States Department of Commerce in all proper efforts to standardize equipments. It was stated that engineers had only themselves to blame for not claiming their birthright in helping to decide questions pertaining to engineering equipments as used by the public; and that if they did claim their rights, possibly the lawyers and the fire-protection people would be glad to give them the right of way.

David C. Fenner[8] said that it seemed to him that in the operation of fire-fighting apparatus in general, the question of administration at fires, the planning for fighting fires, and the actual management of fire fighting left a wide-open field for the management engineer. There was very little of management engineering even in our larger fire-fighting forces today.

The War Industries Board, during the war, had made an attempt to simplify the type and size of extinguishers and fire hose, and had even gone so far as to get into the question of motor-driven apparatus. Unfortunately the armistice had put an end to the sessions of the manufacturers and the Board at that time, but in the last few months it had been learned from the United States Department of Commerce that a further attempt was to be made. It was a live subject at the present time.

F. B. Shattuck[9] said that since the introduction of motor-propelled apparatus the companies making such apparatus had not made any improvements of any consequence in the way of incorporating modern engineering practice in the construction of their power units, and it was a question as to whether there had been any change in their pump units.

Beyond question the piston type of pump was the most efficient prime mover of water that had ever been built. Possibly the rotary pump would come next, it being in effect a piston pump with a rotary rather than a reciprocating motion.

Fire-engine motive power had changed suddenly from steam with its constant torque and its 100 per cent of flexibility, to the gasoline engine, with its intermittent torque and lack of flexibility. And the manufacturers had endeavored to couple an inflexible positive-displacement pump unit with an inflexible power unit, with the result that they had had two absolutely inflexible units trying to work harmoniously together. Using a centrifugal pumping unit, however, this 100 per cent flexibility pump unit would take care of the inflexibility of the power unit, and make a very desirable combination of mechanical units.

The engineer who sat on a committee to consider the type of engine best adapted for the fire department in his city did not consider thoroughly enough the requirements of this unit in the

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[9] Los Angeles, Calif.

fire department, such as the sudden shutting off of lines, and the fact, as stated in the paper, that 95 per cent of the work done in the city was done from the hydrant. He should favor the company which offered down-to-the-minute equipment, and engines and pumps that were suited to each other and best suited to the requirements in his city rather than one that might offer an equipment of higher efficiency. Efficiency alone would not put out fires.

He thought Professor Magruder's idea of standardization of the size of pumping engines was a good one. If it was possible to bring about a one-size engine and a 750-gal. capacity unit, that would be a size which would be manufactured suitably for all. But owing to the National Board of Underwriters, it would be a very hard thing to bring about.

Regarding the matter of the standardization of hose threads, Mr. Shattuck concluded, there were three or four threads which were all recognized by the National Board of Underwriters as being standard.

W. L. Abbott[10] called attention to the failure of manufacturers to standardize their equipment on fittings, particularly on screw threads, so that when one company hurried to a neighboring city to help in a disastrous fire, they would find on arrival that their entire equipment was useless because of their inability to connect hose to the hydrants. That might be taken care of by adapters or some standardization, but it was certainly disastrous in many cases.

R. B. Sargent[11] said that in an experiment he had made it was found that the pulsation in the dome created an emulsion of the air and the water, so that the bubbles gradually leaked out of the bottom until the dome became deaerated and filled with water.

One rotary-pump manufacturer hit upon the idea of filling the air dome full of rubber balls. The diameter of the balls was 2 in. and the walls were about $^1/_4$ in. thick. The effect was very good. The balls no doubt were compressed to about one-fifth their size. Just exactly what shape they would take was a question, since the volume tended to decrease. At any rate the air and the water could not mix. The air remained in the dome and the pump action remained smooth for 12 hours of running. After some 25 or 30 hours of running, no wear could be measured on the balls.

The Author's Closure

The author in closing said, in regard to the discussion presented by Mr. Hollander and Mr. Forward, that the parallel-series type of centrifugal pump undoubtedly had the advantage of a wider range of maximum efficiency and possibly of maximum output from a hydrant. It was doubtful, however, if this gain justified the added complications of passages, bypasses, control valve, etc. One of the most common causes of inefficient operation of positive-displacement pumps was the fact that the operator, in the excitement of the moment, would drive his pump with the wrong ratio of gears for the particular requirements of the occasion. The introduction of the parallel-series valve would be inviting similar inefficient operation of the centrifugal pump.

In reply to the claim that with the fire engine equipped with a parallel-series pump the engine might be operated at practically a constant speed and might use a smaller engine than was used in the conventional fire engine, he said that with this engine working at the peak of its power curve at any pressure there was danger of cutting down the life of the apparatus. There was really no advantage here for the parallel-series pump over the standard multi-stage centrifugal pump which varied the engine speed with the pump pressure. Since pumps were operated by far the greatest percentage of the time at comparatively low pressures, this pressure-speed relation permitted the engine to operate at the lower speeds most of the time with the possibility of longer life. In regard to the gain in efficiency made possible by the use of the parallel-series pump which would have a maximum efficiency of between 70 and 80 per cent, the author said that he had tested conventional 4-stage 750-gal.-per-min. centrifugal fire pumps that maintained an efficiency of 70 per cent or more throughout the range from 120 to 250 lb. per sq. in.

Regarding what Mr. Hampson had said, the specifications that came from many cities had very little evidence of ever having been scanned by an engineer, or by any one who was accustomed to ordinary engineering practice. These specifications pointed out very markedly, in most cases, the standpoint of the lawyer—that of tying everything up very tightly.

As a remedy for this trouble he offered the suggestion that the fire-protection committees in the various cities be made up of engineers who might be appointed by the mayor or other similar official upon the recommendation of the local engineering society or societies.

In England, such matters were turned over to a Board of Engineers absolutely, and that board decided, without any question of any connection with the authorities of the city of political connection, as to what was needed. This not only applied to fire engineering, but to all engineering matters. Perhaps that practice might come to be general in this country at some future time. In one city—Los Angeles—he was informed that there was now a tendency to keep all matters of an engineering nature out of politics.

He agreed with Professor Angus in the statement that positive displacement pumps always cause some pulsation. However, some manufacturers were able to smooth out these pulsations to the extent that they had no effect upon the quality of the fire stream. In answer to the question of the relative life of the packed and unpacked rotary pumps, he stated that there seemed to be little difference in the life of various types of rotary gear pumps, but from curves he had plotted of rotary, centrifugal, and piston pumps manufactured by some five of six companies that had been in service from two to ten years in various cities, he found that the average rotary gear pump after ten years of service would deliver about two-thirds of its rated capacity, while the piston and centrifugal pumps, after a like period, would deliver between ninety and one hundred per cent of their rated capacities.

With reference to Mr. Shattuck's contention that older manufacturers of fire engines had made very few changes, he would grant that they were using slow-speed engines, but this was mainly due to the desire of long life. The engine cylinders were of tee-head construction and had been retained as they permitted the construction of heavy-duty engines which would have a high volumetric efficiency.

The fire engines built by the various manufacturers had been subject to continued improvement and today were in accord with approved automotive and pump design.

In regard to the problem presented by skyscrapers, it was thought that the need of fire engines to pump at very high pressures of 500 or more pounds per square inch in order to protect these buildings was, in many cases, unwise and a solution, which had been mentioned to the author by a prominent engineer, was offered that each skyscraper more than 200 to 400 ft. high be required to provide a centrifugal booster pump in its standpipe lines to aid the fire engines in fighting fires at the tops of these buildings.

[10] Chief Operating Engineer, Commonwealth Edison Co., Chicago, Ill. Past-President A.S.M.E.

[11] Allentown, Pa.

The Influence of Elasticity on Gear-Tooth Loads

Progress Report No. 10 of the A.S.M.E. Special Research Committee on Strength of Gear Teeth[1]

THIS progress report is the seventh of a series of nine reports (Progress Reports Nos. 4 to 12) discussing a possible method of analysis of the test results obtained on the Lewis gear-testing machine, using the various equations developed in the previous progress reports to test their consistency, and deals with the runs made with gears of different materials.

VII TEST RUNS ON GEARS OF DIFFERENT MATERIALS

All of the gears used in this series of tests were of 20-deg. full-depth involute form. The original purpose of these tests was to attempt to determine the maximum load that gears of different materials could carry without excessive wear. The loads and speeds were therefore increased on each run until the surface of the teeth showed signs of distress.

With light loads, the tooth surfaces became highly polished. When a sufficient load was applied, these polished surfaces would lose their smooth polish and appear slightly wavy or broken, an appearance which for lack of a better term we called an "egg-shell" finish. In a few cases where this condition was not detected early enough, definite pitting took place.

When these same gears were run for a little while under a lighter load, the original high polish would be restored—or enough of it so that the same appearance of distress would be seen again when the load was increased sufficiently. Abrasion occurred on the soft cast-aluminum pinion on two or three of the runs. In all other cases the appearance of distress was as described.

The following factors are constant in all of the runs:

f = test load = initial or applied load in pounds
$y_1 = 0.098$ = Lewis factor for number of teeth in pinion
$z_1 = 0.10289$ = elastic form factor for aluminum pinion
$y_2 = 0.130$ = Lewis factor for number of teeth in gear
$z_2 = 0.10975$ = elastic form factor for cast-iron gear
$m_a = 19.25$ = effective mass of solid pulley (Report No. 7)
$R_1 = 3.000$ = radius of pinion
$R_2 = 8.000$ = radius of gear
$p = 1.0472$ = circular pitch

$$f_a = \frac{f_1 \times f_2}{f_1 + f_2} = \text{acceleration load in pounds (Report No. 8)}$$

$f_1 = 0.00055mV^2$ = acceleration load on rigid materials (Report No. 8)

[1] The personnel of the A.S.M.E. Special Research Committee on the Strength of Gear Teeth is as follows:
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Edward W. Miller, Chief Engineer, Fellows Gear Shaper Company, Springfield, Vt.
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We shall now examine the several test runs, using the same equations as before for this purpose. Reports Nos. 4 to 7, inclusive, give the derivation of the various equations proposed for this use, which in effect are brief studies of the dynamics of elastic bodies. The succeeding reports show the application of these equations to the analysis of the test results. Report No. 7 shows in detail the proposed method of determining the effective mass, and Report No. 8 gives a detailed example of the determination of the acceleration load, amount of separation, and the impact load on the gear teeth.

Run AB

Test pinion 3–18–14
Test gear 3–48–5
Aluminum pinion and cast-iron gear
Measured error . . . . 0.0018 in.

$m_p = 0.38$ = effective mass of pinion
$m_2 = 1.00$ = effective mass of test gear
$E_1 = 11{,}000{,}000$ = elastic modulus for aluminum
$E_2 = 15{,}000{,}000$ = elastic modulus for cast iron
$d_t = 0.00000149f$ = static deformation of tooth profile
$f_2 = 1208 + f$ = static load required to deform tooth amount of effective error (Report No. 8)

The log of this run, together with the calculated values as before, is given in Table 1.

Run AC

Test pinion 3–18–12
Test gear 3–48–5
Phosphor-bronze pinion and cast-iron gear
Measured error . . . . 0.0030 in.

$m_p = 0.500$ $E_2 = 15{,}000{,}000$
$m_2 = 1.000$ $d_t = 0.00000130f$
$E_1 = 14{,}000{,}000$ $f_2 = 2308 + f$

The log of this run, together with the calculated values as before, is given in Table 2.

Run AD

Test pinion 3–18–13
Test gear 3–48–5
Manganese-bronze pinion and cast-iron gear
Measured error . . . . 0.0040 in.

$m_p = 0.50$ $E_2 = 15{,}000{,}000$
$m_2 = 1.00$ $d_t = 0.00000130f$
$E_1 = 14{,}000{,}000$ $f_2 = 3077 + f$

The log of this run, together with the calculated values as before, is given in Table 3.

Run AE

Test pinion 3–18–11
Test gear 3–48–5
Machine-steel pinion and cast-iron gear
Measured error . . . . 0.0025 in.

$m_p = 0.500$ $E_2 = 15{,}000{,}000$
$m_2 = 1.000$ $d_t = 0.00000093f$
$E_1 = 30{,}000{,}000$ $f_2 = 2688 + f$

The log of this run, together with the calculated values as before, is given in Table 4.

RUN AG

Test pinion................3-18-14
Test gear....................3-48-8
Aluminum pinion and aluminum gear
Measured error...........0.0025 in.

$m_p = 0.38$ $d_t = 0.00000171f$
$m_2 = 0.56$ $f_2 = 1462 + f$
$E_1, E_2 = 11{,}000{,}000$

The log of this run, together with the calculated values as before, is given in Table 5.

RUN AH

Test pinion........................3-18-12
Test gear..........................3-48-8
Phosphor-bronze pinion and aluminum gear
Measured error...................0.0030 in.

$m_p = 0.50$ $E_2 = 11{,}000{,}000$
$m_2 = 0.56$ $d_t = 0.00000152f$
$E_1 = 14{,}000{,}000$ $f_2 = 1974 + f$

The log of this run, together with the calculated values as before, is given in Table 6.

RUN AI

Test pinion........................3-18-13
Test gear..........................3-48-8
Manganese-bronze pinion and aluminum gear
Measured error...................0.0028 in.

$m_p = 0.50$ $E_2 = 11{,}000{,}000$
$m_2 = 0.56$ $d_t = 0.00000152f$
$E_1 = 14{,}000{,}000$ $f_2 = 1842 + f$

The log of this run, together with the calculated values as before is given in Table 7.

RUN AJ

Test pinion........................3-18-11
Test gear..........................3-48-8
Machine-steel pinion and aluminum gear
Measured error...................0.0031 in.

$m_p = 0.50$ $E_2 = 11{,}000{,}000$
$m_2 = 0.56$ $d_t = 0.00000115f$
$E_1 = 30{,}000{,}000$ $f_2 = 2695 + f$

The log of this run, together with the calculated values as before, is given in Table 8.

RUN AL

Test pinion........................3-18-14
Test gear..........................3-48-6
Aluminum pinion and phosphor-bronze gear
Measured error...................0.0015 in.

$m_p = 0.38$ $E_2 = 14{,}000{,}000$
$m_2 = 1.00$ $d_t = 0.00000153f$
$E_1 = 11{,}000{,}000$ $f_2 = 980 + f$

The log of this run, together with the calculated values as before, is given in Table 9.

RUN AM

Test pinion............................3-18-12
Test gear..............................3-48-6
Phosphor-bronze pinion and phosphor-bronze gear
Measured error.......................0.0035 in.

$m_p = 0.50$ $d_t = 0.00000135f$
$m_2 = 1.00$ $f_2 = 2593 + f$
$E_1, E_2 = 14{,}000{,}000$

The log of this run, together with the calculated values as before, is given in Table 10.

RUN AN

Test pinion..............................3-18-13
Test gear................................3-48-6
Manganese-bronze pinion and phosphor-bronze gear
Measured error.........................0.0033 in.

$m_p = 0.50$ $d_t = 0.00000135f$
$m_2 = 1.00$ $f_2 = 2444 + f$
$E_1, E_2 = 14{,}000{,}000$

The log of this run, together with the calculated values as before, is given in Table 11.

RUN AO

Test pinion............................3-18-11
Test gear..............................3-48-6
Machine-steel pinion and phosphor-bronze gear
Measured error.......................0.0018 in.

$m_p = 0.50$ $E_2 = 14{,}000{,}000$
$m_2 = 1.00$ $d_t = 0.00000098f$
$E_1 = 30{,}000{,}000$ $f_2 = 1837 + f$

The log of this run, together with the calculated values as before, is given in Table 12.

RUN AQ

Test pinion........................3-18-14
Test gear..........................3-48-7
Aluminum pinion and manganese-bronze gear
Measured error...................0.0014 in.

$m_p = 0.38$ $E_2 = 14{,}000{,}000$
$m_2 = 1.00$ $d_t = 0.00000153f$
$E_1 = 11{,}000{,}000$ $f_2 = 915 + f$

The log of this run, together with the calculated values as before, is given in Table 13.

RUN AR

Test pinion............................3-18-12
Test gear..............................3-48-7
Phosphor-bronze pinion and manganese-bronze gear
Measured error.......................0.0038 in.

$m_p = 0.50$ $d_t = 0.00000135f$
$m_2 = 1.00$ $f_2 = 2815 + f$
$E_1, E_2 = 14{,}000{,}000$

The log of this run, together with the calculated values as before, is given in Table 14.

RUN AS

Test pinion................................3-18-13
Test gear..................................3-48-7
Manganese-bronze gear and manganese-bronze pinion
Measured error...........................0.0033 in.

$m_p = 0.50$ $d_t = 0.00000135f$
$m_2 = 1.00$ $f_2 = 2444 + f$
$E_1, E_2 = 14{,}000{,}000$

The log of this run, together with the calculated values as before, is given in Table 15.

RUN AT

Test pinion................................3-18-11
Test gear..................................3-48-7
Machine-steel pinion and manganese-bronze gear
Measured error...........................0.0025 in.

$m_p = 0.50$ $E_2 = 14{,}000{,}000$
$m_2 = 1.00$ $d_t = 0.00000098f$
$E_1 = 30{,}000{,}000$ $f_2 = 2551 + f$

RUN AV

Test pinion................3-18-14
Test gear...................3-48-4
Aluminum pinion and cast-steel gear
Measured error...........0.0018 in.

$m_p = 0.38$	$E_2 = 30{,}000{,}000$
$m_2 = 1.00$	$d_t = 0.00000118f$
$E_1 = 11{,}000{,}000$	$f_2 = 1525 + f$

RUN AW

Test pinion........................3-18-12
Test gear...........................3-48-4
Phosphor-bronze pinion and cast-steel gear
Measured error...................0.0035 in.

$m_p = 0.50$	$E_2 = 30{,}000{,}000$
$m_2 = 1.00$	$d_t = 0.00000099f$
$E_1 = 14{,}000{,}000$	$f_2 = 3535 + f$

RUN AX

Test pinion........................3-18-13
Test gear...........................3-48-4
Manganese-bronze pinion and cast-steel gear
Measured error...................0.0035 in.

$m_p = 0.50$	$E_2 = 30{,}000{,}000$
$m_2 = 1.00$	$d_t = 0.00000099f$
$E_1 = 14{,}000{,}000$	$f_2 = 3535 + f$

RUN AY

Test pinion....................3-18-11
Test gear.......................3-48-4
Machine-steel pinion and cast-steel gear
Measured error...............0.0015 in.

$m_p = 0.50$	$d_t = 0.00000062f$
$m_2 = 1.00$	$f_2 = 2419 + f$
$E_1, E_2 = 30{,}000{,}000$	

The logs of runs AV–AY, together with the calculated values as before, are given in Tables 16–20.

SUMMARY

The calculated amounts of separation on these runs show considerable variation, but are within the range of separation which might be expected on the testing machine. The maximum impact loads when signs of distress appeared are reasonably consistent when the materials are similar. In the next progress report we shall examine the runs where signs of distress appeared by determining the maximum compressive stresses that will exist when the calculated impact loads are imposed.

LOGS OF RUNS AB TO AY AND CALCULATED DATA

TABLE 1 RUN AB—ALUMINUM PINION AND CAST-IRON GEAR

Run No.	V	f	m	f_a	k	F
AB-1	177	44	0.893	14.8	0.000569	232.5
AB-2	375	109	0.815	60.1	0.000887	485.4
AB-3	503	121	0.770	99.0	0.001322	599.8
AB-4	503	150	0.769	99.2	0.001030	629.3
AB-5	584	236	0.739	126.8	0.000741	774.8
AB-6	605	265	0.731	133.7	0.000660	817.0
AB-7	628	303	0.722	142.2	0.000569	871.4
AB-8	670	325	0.708	157.1	0.000571	920.7
AB-9	945	383[1]	0.629	258.7	0.000800	1129.5

[1] Pinion showed signs of distress.

TABLE 2 RUN AC—PHOSPHOR-BRONZE PINION AND CAST-IRON GEAR

Run No.	V	f	m	f_a	k	F
AC-1	244	65	0.889	28.6	0.001270	427.2
AC-2	306	91	0.870	44.2	0.001384	540.5
AC-3	433	117	0.833	83.1	0.002016	730.7
AC-4	535	143	0.805	120.7	0.002373	879.5
AC-5	545	169	0.802	124.4	0.002039	916.5
AC-6	590	225	0.789	142.5	0.001695	1023.3
AC-7	612	261	0.783	151.5	0.001515	1083.4
AC-8	1080	287[1]	0.678	372.5	0.003393	1544.3
AC-9	1140	373[1]	0.664	403.5	0.002719	1676.3

[1] Pinion showed signs of distress.

TABLE 3 RUN AD—MANGANESE-BRONZE PINION AND CAST-IRON GEAR

Run No.	V	f	m	f_a	k	F
AD-1	239	61	0.901	27.8	0.001775	473.7
AD-2	335	92	0.875	53.1	0.002229	661.1
AD-3	420	120	0.853	80.9	0.002583	820.9
AD-4	540	160	0.823	127.7	0.003022	1037.1
AD-5	558	190	0.819	134.2	0.002640	1088.9
AD-6	900	270	0.743	301.2	0.004068	1597.6
AD-7	915	376[1]	0.738	309.5	0.002882	1720.6

[1] Pinion showed signs of distress.

TABLE 4 RUN AE—MACHINE-STEEL PINION AND CAST-IRON GEAR

Run No.	V	f	m	f_a	k	F
AE-1	600	178	0.773	145.2	0.001901	1049.5
AE-2	1045	290	0.667	353.4	0.002711	1622.0
AE-3	1140	344	0.647	400.9	0.002536	1756.1
AE-4	1250	400	0.626	458.2	0.002434	1901.6
AE-5	2000	450	0.523	842.1	0.003736	2403.9
AE-6	1860	506	0.537	774.3	0.003039	2393.9
AE-7	1900	530	0.532	795.1	0.002949	2438.5
AE-8	1925	555	0.529	809.1	0.002838	2477.5
AE-9	1960	640[1]	0.523	829.6	0.002443	2582.4

[1] Pinion showed signs of distress.

TABLE 5 RUN AG—ALUMINUM PINION AND ALUMINUM GEAR

Run No.	V	f	m	f_a	k	F
AG-1	175	35	0.523	8.9	0.000604	196.1
AG-2	274	70	0.508	20.7	0.000674	315.1
AG-3	350	84	0.497	32.3	0.000879	389.7
AG-4	500	105	0.476	62.4	0.001364	527.5
AG-5	597	145	0.463	86.1	0.001317	639.3
AG-6	650	170	0.456	99.5	0.001268	700.1
AG-7	770	215	0.441	132.6	0.001288	823.5
AG-8	785	235	0.439	137.0	0.001188	852.8
AG-9	1075	255	0.409	225.8	0.001825	1035.6
AG-10	1160[1]	307[1]	0.400	253.6	0.001624	1130.1

[1] Pinion showed abrasion.

TABLE 6 RUN AH—PHOSPHOR-BRONZE PINION AND ALUMINUM GEAR

Run No.	V	f	m	f_a	k	F
AH-1	167	25	0.526	8.0	0.000939	202.5
AH-2	267	42	0.513	19.8	0.001375	294.9
AH-3	374	80	0.499	37.3	0.001325	461.9
AH-4	465	107	0.487	56.4	0.001477	575.3
AH-5	520	124	0.481	69.6	0.001560	643.4
AH-6	590	141	0.473	87.2	0.001707	721.2
AH-7	700	178	0.460	117.2	0.001781	847.8
AH-8	760	215	0.454	135.1	0.001657	932.7
AH-9	910	258	0.438	182.7	0.001830	1087.2
AH-10	1140	285	0.418	264.1	0.002377	1271.1
AH-11	1450	402[1]	0.393	381.2	0.002265	1567.8

[1] Gear showed signs of distress.

TABLE 7 RUN AI—MANGANESE-BRONZE PINION AND ALUMINUM GEAR

Run No.	V	f	m	f_a	k	F
AI-1	184	25	0.523	9.9	0.001087	215.8
AI-2	285	44	0.509	22.7	0.001402	332.3
AI-3	405	77	0.493	43.0	0.001487	472.8
AI-4	510	121	0.480	66.7	0.001423	612.0
AI-5	570	140	0.473	81.5	0.001487	681.8
AI-6	718	188	0.456	121.3	0.001604	845.4
AI-7	880	237	0.438	171.6	0.001753	1013.4
AI-8	890	265	0.437	174.3	0.001553	1047.0
AI-9	1090	284	0.419	242.7	0.002019	1197.6
AI-10	1250	353	0.405	300.4	0.001920	1361.5
AI-11	1750	472[1]	0.370	490.8	0.002165	1724.2

[1] Gear showed signs of distress.

TABLE 8 RUN AJ—MACHINE-STEEL PINION AND ALUMINUM GEAR

Run No.	V	f	m	f_a	k	F
AJ-1	179	21	0.525	9.0	0.001314	241.0
AJ-2	314	51	0.507	26.7	0.001585	429.4
AJ-3	419	82	0.494	47.2	0.001722	584.3
AJ-4	465	112	0.489	56.8	0.001491	662.4
AJ-5	610	143	0.472	93.8	0.001916	847.8
AJ-6	695	173	0.463	117.9	0.001967	961.4
AJ-7	760	234	0.455	138.2	0.001649	1086.0
AJ-8	1075	294	0.426	248.5	0.002330	1424.1
AJ-9	1145	355	0.419	274.8	0.002073	1541.1
AJ-10	1350	415	0.403	357.6	0.002255	1756.7
AJ-11	1680	475[1]	0.375	491.7	0.002643	2027.3

[1] Gear showed signs of distress.

TABLE 9 RUN AL—ALUMINUM PINION AND PHOSPHOR-BRONZE GEAR

Run No.	V	f	m	f_a	k	F
AL-1	245	73	0.856	27.3	0.000497	302.7
AL-2	344	103	0.814	50.5	0.000638	413.8
AL-3	380	133	0.798	59.6	0.000550	469.5
AL-4	420	174	0.781	71.3	0.000459	541.1
AL-5	525	214	0.740	102.4	0.000517	650.6
AL-6	580	285	0.717	120.3	0.000376	755.0
AL 7	965	365	0.599	250.0	0.000617	1019.1
AL-8	1140	406	0.556	308.6	0.000650	1119.7
AL-9	1508	446	0.487	426.7	0.000782	1255.0
AL-10	1675	487	0.461	478.9	0.000742	1329.0
AL-11	1675	508[1]	0.459	479.7	0.000681	1350.3

[1] Pinion showed signs of distress.

TABLE 10 RUN AM—PHOSPHOR-BRONZE PINION AND PHOSPHOR-BRONZE GEAR

Run No.	V	f	m	f_a	k	F
AM-1	280	69	0.885	37.5	0.001842	508.3
AM-2	375	92	0.858	64.4	0.002357	666.2
AM-3	480	158	0.830	101.1	0.002089	874.8
AM-4	495	189	0.825	112.3	0.001910	944.2
AM-5	580	235	0.800	140.6	0.001879	1077.0
AM-6	1110	436	0.686	403.1	0.002690	1824.2
AM-7	1160	572	0.673	430.3	0.002028	2002.0
AM-8	2210	608[1]	0.533	989.4	0.004198	2645.4
AM-9	2100	674[1]	0.543	938.6	0.003992	2780.9

[1] Pinion showed signs of distress.

TABLE 11 RUN AN—MANGANESE-BRONZE PINION AND PHOSPHOR-BRONZE GEAR

Run No.	V	f	m	f_a	k	F
AN-1	223	71	0.899	24.8	0.001099	418.3
AN-2	295	97	0.878	41.3	0.001328	544.5
AN-3	360	122	0.859	59.6	0.001510	658.6
AN-4	480	162	0.826	100.9	0.001903	857.0
AN-5	500	182	0.820	108.3	0.001797	899.4
AN-6	580	243	0.798	140.3	0.001687	1059.2
AN-7	700	288	0.768	19.4	0.001924	1239.0
AN-8	900	323	0.718	286.8	0.002540	1471.9
AN-9	1040	523	0.690	360.2	0.001752	1799.6
AN-10	1850	623	0.564	788.8	0.003083	2421.0
AN-11	2560	674[1]	0.495	1134.7	0.003811	2738.5

[1] Pinion showed signs of distress.

TABLE 12 RUN AO—MACHINE-STEEL GEAR AND PHOSPHOR-BRONZE GEAR

Run No.	V	f	m	f_a	k	F
AO-1	314	92	0.841	45.9	0.000842	500.1
AO-2	350	110	0.827	54.4	0.000823	553.7
AO-3	430	138	0.799	77.8	0.000926	667.0
AO-4	475	165	0.783	92.5	0.000903	740.7
AO-5	500	192	0.774	100.7	0.000824	791.8
AO-6	560	220	0.755	122.3	0.000860	879.3
AO-7	835	247	0.678	231.2	0.001458	1139.2
AO-8	1140	364	0.607	359.7	0.001426	1456.0
AO-9	1195	490	0.592	387.6	0.001033	1618.0
AO-10	1800	527[1]	0.504	650.8	0.001571	1929.3

[1] Both gear and pinion showed signs of distress.

TABLE 13 RUN AQ—ALUMINUM PINION AND MANGANESE-BRONZE GEAR

Run No.	V	f	m	f_a	k	F
AQ-1	192	54	0.876	17.7	0.000413	233.1
AQ-2	333	93	0.812	47.6	0.000627	384.3
AQ-3	385	132	0.791	60.3	0.000517	458.3
AQ-4	490	161	0.749	90.7	0.000627	558.3
AQ-5	545	190	0.727	107.4	0.000600	620.4
AQ-6	580	249	0.711	118.6	0.000433	699.2
AQ-7	600	268	0.703	124.3	0.000400	728.4
AQ-8	670	287	0.678	146.6	0.000438	783.2
AQ-9	1000	305	0.585	254.8	0.000773	938.2
AQ-10	1140	394	0.510	285.4	0.000555	1057.9
AQ-11	1610	483[1]	0.460	446.5	0.000609	1269.3

[1] Pinion showed abrasion.

TABLE 14 RUN AR—PHOSPHOR-BRONZE PINION AND MANGANESE-BRONZE GEAR

Run No.	V	f	m	f_a	k	F
AR-1	188	61	0.913	17.9	0.001070	377.8
AR-2	340	85	0.872	54.0	0.002334	633.8
AR-3	455	134	0.841	93.0	0.002503	851.4
AR-4	490	193	0.832	106.1	0.001919	958.4
AR-5	545	232	0.818	128.3	0.001897	1072.1
AR-6	760	291	0.767	226.2	0.002639	1396.5
AR-7	1250	450	0.668	488.1	0.003461	2034.0
AR-8	1670	660[1]	0.603	730.5	0.003215	2552.2

[1] Pinion showed signs of distress.

TABLE 15 RUN AS—MANGANESE-BRONZE PINION AND MANGANESE-BRONZE GEAR

Run No.	V	f	m	f_a	k	F
AS-1	169	52	0.915	13.9	0.000844	312.3
AS-2	255	75	0.890	31.6	0.001331	466.7
AS-3	375	102	0.855	64.3	0.001984	658.9
AS-4	440	150	0.837	86.0	0.001757	792.6
AS-5	500	177	0.820	108.3	0.001865	898.5
AS-6	575	205	0.800	137.5	0.002013	1013.3
AS-7	645	232	0.783	167.8	0.002148	1122.2
AS-8	720	290	0.764	201.9	0.002007	1262.7
AS-9	920	318	0.719	298.8	0.002697	1488.9
AS-10	1050	386	0.691	365.0	0.002627	1671.0
AS-11	1160	524	0.668	423.5	0.002082	1899.5
AS-12	2460	652[1]	0.503	1086.5	0.003837	2694.9

[1] Pinion showed signs of distress.

TABLE 16 RUN AT—MACHINE-STEEL PINION AND MANGANESE-BRONZE GEAR

Run No.	V	f	m	f_a	k	F
AT-1	190	50	0.900	17.9	0.000867	351.6
AT-2	312	99	0.860	45.2	0.001083	577.2
AT-3	375	128	0.839	63.5	0.001162	693.6
AT-4	480	158	0.807	98.3	0.001448	859.2
AT-5	525	187	0.794	115.0	0.001411	944.4
AT-6	557	226	0.784	127.8	0.001268	1023.3
AT-7	628	305	0.763	156.9	0.001097	1185.8
AT-8	750	345	0.731	209.6	0.001287	1357.2
AT-9	1350	374	0.609	504.7	0.002857	1897.3
AT-10	1140	503	0.643	399.8	0.001585	1874.2
AT-11	1875	602[1]	0.532	775.8	0.002437	2433.9

[1] Both gear and pinion showed signs of distress.

TABLE 17 RUN AV—ALUMINUM PINION AND CAST-STEEL GEAR

Run No.	V	f	m	f_a	k	F
AV-1	185	42	0.890	16.8	0.000691	267.8
AV-2	306	70	0.842	41.9	0.001021	425.0
AV-3	380	109	0.814	62.5	0.000947	541.3
AV-4	465	148	0.778	88.1	0.000953	658.7
AV-5	530	206	0.759	109.6	0.000802	773.9
AV-6	610	275	0.711	135.0	0.000682	902.0
AV-7	930	303	0.617	253.3	0.001201	1144.7
AV-8	1170	362[1]	0.559	344.2	0.001305	1327.1

[1] Pinion showed signs of distress.

TABLE 18 RUN AW—PHOSPHOR-BRONZE PINION AND CAST-STEEL GEAR

Run No.	V	f	m	f_a	k	F
AW-1	202	58	0.907	19.9	0.001169	432.6
AW-2	343	87	0.867	55.1	0.002156	708.6
AW-3	428	131	0.844	83.1	0.002129	892.9
AW-4	472	165	0.832	99.3	0.001995	996.8
AW-5	550	194	0.812	130.2	0.002210	1144.6
AW 6	572	238	0.806	139.6	0.001895	1221.9
AW-7	915	323	0.728	308.2	0.003034	1766.5
AW-8	1200	472[1]	0.671	468.9	0.003013	2231.6

[1] Pinion showed signs of distress.

TABLE 19 RUN AX—MANGANESE-BRONZE PINION AND CAST-STEEL GEAR

Run No.	V	f	m	f_a	k	F
AX-1	196	58	0.909	18.9	0.001109	423.1
AX-2	315	87	0.875	47.4	0.001851	664.0
AX-3	420	141	0.846	80.2	0.001898	889.6
AX-4	535	185	0.816	123.8	0.002210	1112.4
AX-5	570	215	0.807	138.7	0.002107	1195.6
AX-6	592	295	0.800	148.0	0.001573	1307.1
AX-7	630	345	0.791	165.6	0.001470	1414.5
AX-8	900	375	0.730	300.1	0.002497	1800.4
AX-9	1000	434	0.709	355.1	0.002505	1978.2
AX-10	1250	564[1]	0.661	498.9	0.002598	2375.0

[1] Gear showed signs of distress.

TABLE 20 RUN AY—MACHINE-STEEL PINION AND CAST-STEEL GEAR

Run No.	V	f	m	f_a	k	F
AY-1	270	77	0.848	33.5	0.000624	478.2
AY-2	375	125	0.806	60.5	0.000678	662.6
AY-3	480	192	0.767	93.5	0.000657	858.2
AY-4	575	235	0.735	127.6	0.000720	1010.0
AY-5	755	287	0.680	197.5	0.000901	1244.4
AY-6	885	320	0.646	252.4	0.001022	1395.8
AY-7	970	457	0.623	289.6	0.000752	1605.0
AY-8	1125	505	0.589	359.6	0.000832	1773.6
AY-9	1550	557	0.519	557.5	0.001156	2101.6
AY-10	1675	630	0.502	617.9	0.001088	2244.7
AY-11	1650	721[1]	0.504	608.7	0.000883	2325.2

[1] Gear showed signs of distress.

Foreman Training

Two Papers[1] Dealing Respectively with Improvement of Foremanship by the Conference Method and with Education for Foremanship

Improvement of Foremanship by the Conference Method

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IN SELECTING a topic on foremanship for discussion at this meeting the author has chosen a phase of foremanship improvement of which he has direct personal knowledge. The points of view expressed here are a result of the personal experience of the author and his associates on the Federal Board staff in conducting foremanship conferences with different types of industries at different points throughout the country, together with experiences reported by state officials and industrial-plant officials trained by representatives of the Federal Board to conduct similar work in their own states, communities, and plants. This paper accordingly represents experience gained by the conference method in working with several thousand foremen in representative American industries.

The Conference Method

The discussion in this paper deals primarily with the conference method as a method rather than with the type of subject matter usually covered in foremanship conferences. In the author's opinion there has been much needless mystery and glamour cast around certain so-called "methods," when a brief examination will disclose the fact that there is nothing new in them—they represent at best new applications of old, well-established principles. The conference, for example, is as old as industry itself. When Bill Smith approaches John Jones at his work and informs him that he has a job which he is not quite able to plan through so as to handle it with the facilities at his disposal, and the two men proceed to discuss the problem in the light of their past experiences and combined intelligence, and eventually work out a solution which is satisfactory, they have had a conference in the true sense of the word. What has come to be known as the conference method of improving foremanship is accordingly but a recognition of the value of this time-tested procedure for certain purposes, and an application of it to a purposeful, organized plan of improving certain phases of foremanship.

Theories of Foreman Training Compared

An examination of the field will disclose the fact that there have been two main theories followed in devising different types of courses and choosing different methods for training foremen in one or another phase of their jobs. The first theory, for purposes of discussion, may be termed the "arbitrary set-up" type. This theory proceeds on the basis that management, in its administration of industry, has become well acquainted with certain shortcomings and the need for further training on the part of foremen, and that management can accordingly formulate courses of training, arbitrarily chosen by self-styled management experts, as being exactly what are needed by the foremen. Courses constructed in harmony with this theory have usually been built by having various plant executives, technical experts, and personnel men write on various phases of the foreman's job. Such courses have then been placed before the foremen through such methods as letters sent out periodically from a central source, lectures delivered by special lecturers or "high-powered" executives, books to be studied by the foremen in connection with lectures or discussions following upon the reading of assignments, and as straight correspondence courses. Such courses embrace in their scope almost every phase imaginable; from the straight imparting of detailed technical information, through studies of various technical processes, on into personnel work, the handling of men, theories as to wage setting and rates, etc., into the final climax: the management of industry itself. An important phase of some of these courses is the prodigal use of snappy stories and jokes, of "wise cracks," and of high-sounding platitudes attributed to various self-made "captains of industry."

The second theory, which may be styled the "trouble-shooting" theory, proceeds on the basis that a given group of foremen are their own best judges as to their own paramount needs, and that the topics which can be most profitably considered with a given group in order to assist in improving the foremanship of that group will come spontaneously from the foremen themselves, if the person in charge is competent to handle the group properly. Any phase of foremanship, even to the question of solving a detailed technical problem, can come up and be dealt with in the group at the time that interest is at a high point, if the course is being conducted on this basis. It is with a deliberate commitment to this theory that the conference method has been applied to the problem of improving foremanship. As a result, one of the characteristics of the conference method as applied to foremanship is to be found in the fact that there is no set course to be covered by a given group of foremen. The members making up an individual group determine for themselves the subjects which will be discussed, and the extent of the discussion for a given subject. This characteristic has sometimes been referred to by advocates of other methods of improving foremanship as a disadvantage. The adjective "haphazard" has been applied to round-table conferences, with a view to creating a negative impression, in a recent article delivered before the Kansas City meeting of this Society. Yet the article alluded to heralded "a true basis for the development of foremen," which upon examination is seen to be but the application of the conference method to the solving of detailed technical problems or "daily difficulties" as reported by the foremen to a representative committee, and there duly considered and solved, if possible, by the use of the conference method.

It is quite true that a conference leader cannot predict before beginning work with a group what particular phases of foremanship a group will care to consider, or what relative emphasis will be spent by the group upon one phase of the work or another. A conference leader when operating a conference does not attempt to force a group to confer about something in which they are not really interested. If he persists, the conference will cease. He may go ahead and attempt to lecture them on some topic in which he thinks they should be interested, but in such a case he is using the lecture method. The foremen are directly on the job. They know their own limitations and where they would appreciate a little outside assistance. If handled properly there

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will be no dearth of interesting and valuable material put up for discussion and solution by the foremen themselves. Advocates of the conference method accordingly believe this feature to be one of the strongest talking points for the method, since it is essentially from this angle a "trouble-shooting" course which will bring out from the group many difficulties and problems existing in the minds of the foremen of which the management is oftentimes entirely unaware, and which no outside "expert" could possibly anticipate.

Some Comparison of Methods

The methods which are used in foreman training may be divided into four main types, although many modifications and combinations exist. These types are: the lecture course, the textbook course, the correspondence course, and the conference. A brief comparison of some of the main characteristics of these types may be useful in estimating the relative value of the different methods for various purposes. The usual purpose in giving work to foremen under the first three methods is promotional, while in the conference the purpose is improvement on the job. The subject-matter discussed under the first three methods is determined by the lecturer or the authors, while in the conference the men in the group determine it. The subjects discussed, by the very nature of the methods used, have to be handled in a general way by the lecture and written course methods so that they do not fit specific situations, while the conference concerns itself particularly with the solving of the specific situations which exist in a given plant. The thinking required of the foremen comprising a group may be largely passive where the lecture or textbook methods are used, and may be partly passive in correspondence work if the subject-matter is concerned with the imparting of information to any extent, but the conference method demands active thinking on the part of each individual member of the group, if the person conducting the work is skilled in handling the method. The first three methods are unable to stimulate much if any individual thinking about specific problems, but the value of the conference is high in this respect. The size of the group to be reached is unlimited in the case of the lecture course, while it is limited where any of the remaining methods are used. The principal faculty exercised on the part of the men taking the work is memory in the case of the lecture course, memory and the ability to refer and apply in the case of the textbook and correspondence courses, while the conference requires the exercise of the thinking ability of the group members. The final product arising from the conducting of a foremanship course by the use of one of these methods may be summed up as follows: a gain of information and a temporary enthusiasm as a result of the lecture method; increased information and knowledge with a need for considering factors where textbooks are used; increased information and knowledge and some increase in ability to solve problems or diagnose difficulties where the foreman carries a correspondence course through to completion; and better reasoning ability on the job as a result of participating in a series of conferences.

It should be emphasized in this connection that the persons advocating the use of the conference method for the improving of foremanship have no quarrel with persons advocating other types or methods of attaining the same results, even where a set course is laid out by plant executives as something which they believe the foremen should be taught. Such a course may be the thing most needed in a given case. There is undoubtedly a legitimate place in an educational program for foremen for practically every method and type of course which has been devised up to the present time, and under certain circumstances some good is done even with the use of a relatively inefficient method. If it is felt that the prime need of a given group of foremen is additional information along some line or increased technical knowledge, it would not only be a waste of time but a mistake as well to attempt to utilize the conference method for this purpose. The person conducting a series of conferences does not at any time pose as a technical expert. The relationship of teacher or expert to students or pupils is expressly disavowed and avoided, the group and its leader meeting on one level and considering the problems presented on an equal basis, with every man's opinion valued as highly as the other man's opinion, whenever he can furnish facts as a basis for them. The assumption is made from the beginning, and announced to the group of foremen, that they are considered entirely competent to operate their own technical production, and that the leader is in the group primarily to assist them in considering various phases of their work, so as to bring about a pooling of experiences and a combining of the intelligence of the group members in order to properly evaluate the factors involved and work out rational decisions or plans.

Conference Deals with Common Problems

In the improvement of foremanship by the conference method, the one thing standard, no matter what the industry or the circumstances may be, is the method itself, not the subject-matter discussed. In one sense of the word, the conference method is a course in constructive intelligent thinking; that is, a course designed to assist those participating in thinking more intelligently through problems embracing several factors from which a rational decision is desired, on the basis of an evaluation of those factors by the combined intelligence and experiences of the group. It is evident that participation in this type of work requires active thinking on the part of each individual member. If the minds of the participants become passive, the conference ceases. Accordingly the topics discussed by this method must of necessity have some vital common interest, in order that active participation by each member of the group may continue. The conference method, as it has been customarily used in the improvement of foremanship work, has therefore been applied to a consideration of the intelligent discharge of those supervisory and managerial responsibilities which all foremen have more or less in common, regardless of the type of industry or the nature of the production problems arising in their various departments. There are persons, to be sure, who deny that foremen have any such responsibilities in common. Charles R. Allen's book, "The Foreman and His Job," has been recently mentioned in print as promoting a misconception which is impliedly leading persons astray in conducting foremanship work, because of a statement in the book to the effect that "the problems with which any executive or supervisor has to deal are largely independent of the particular kind of work that he has under his direction." This statement has been challenged evidently because the person making the charge was confusing detailed technical production problems with the supervisory and managerial responsibilities of which such problems are but specific applications. At any rate the experience recorded in conducting successful conferences on the basis of a discussion of common responsibilities with thousands of foremen in different types of industries throughout the country is a sufficient answer to such a charge and justification for the premise set forth.

One of the primary tests as to whether a given subject or topic may be handled effectively with a given group of foremen by the conference method lies in the fact that it either does or does not have a common interest and appeal to the majority of the group and is within the range of their experiences. With this test answered in the affirmative, the conference method has been

found to be of real value in solving technical production problems of a type which could not be solved by a standard formula, but which required the evaluation of factors and exercise of judgment for a satisfactory solution. The solving of technical problems is a phase of the entire program of improving foremenship which has been recognized by industry for years, and discussions on an informal conference basis have been held from time to time in various plants on technical production problems entirely irrespective of any organized program for improving the foremen as a whole. It is true that the average series of conferences on improving foremenship does not include much consideration of such problems in its scope, because of the lack of common interest or appeal to foremen coming from technical and service departments as well as the production departments represented in the average group gathered together to consider foremanship. Where a production problem arises during a series of conferences which is of real common interest to a majority of the foremen, the method may be used quite effectively in its consideration and solution. For an interesting adaptation of the conference method to an organized program for the solving of technical production problems in a plant or industry, the reader is referred to the address entitled, "Industrial Problems or Difficulties," delivered by L. A. Hartley before the Kansas City meeting of the Society this spring.

Heavy Emphasis on Human-Factor Problems

Some estimates as to the limitations of the conference method as applied to foremanship have been based upon an examination of various reports of different conferences in different-type industries. Such reports will disclose the fact that almost invariably the larger percentage of the time spent in such conferences has been devoted to a consideration of the foreman's responsibilities on the human factor and morale side rather than on technical production difficulties. This fact may be due to any one of the following circumstances: first, the management of a given plant may have studied a report of another series of conferences, become convinced that their foremen needed a discussion of the same topics, and hence have asked the conference leader to conduct the conference around these general topics; second, the conference leader may have been comparatively new in this field of work, and imitated the work of some other leader on topics which from their recurrence in various reports he has reason to believe will be "sure fire" in capturing the common interest of the group; third, the choice of topics may have been due to the paramount need of the foremen in a given group as they felt it and expressed it to the group leader. The third cause, just mentioned, is by far the largest factor in determining the general type of topics covered in a series of conferences on foremanship.

While it is entirely possible to use the conference method in handling technical production problems with a group of foremen who have those problems to solve, the fact remains that the average foreman considers himself satisfactorily competent in his ability to handle the production problems arising in his department, but does appreciate assistance on the personnel side of his job and feels that a consideration of this phase of his work is of major importance to him. This feeling on the part of the foreman is but natural when one considers the fact that the average foreman in American industry has been chosen from among the really superior workmen, who are thoroughly conversant with the technical processes in their own departments. As foreman he is now called upon, not to do a superior type of work himself, but to so handle the men under him that they will produce high-grade work for him. In other words, the factor which has caused his promotion is of no direct value to him in getting the work done through other people. Its primary value lies in the fact that he is familiar with the technical processes, he knows what good work is, and what a day's labor really covers; yet, if he is unable to solve the problem of handling his help effectively, his superior workmanship as a worker will avail him but little as a foreman. Consequently a group of such foremen, when assembled to consider their jobs and invited to discuss those angles which cause them some difficulty, or take an excessive amount of time to administer, will almost invariably choose to discuss those topics which deal with handling their help in such a manner as to have satisfied, willing workers with a minimum of friction and jarring.

The average technical problem can be solved almost mathematically according to standard procedure when all factors are secured. This is not true when it comes to considering the matter of solving problems affecting the behavior of human beings. Every observant individual is a student of applied psychology from birth to death, yet every such individual is constantly confronted with reactions from other persons under different circumstances which emphasize the fact that there is no standard formula for the solution of any situation affecting human beings. The foreman quickly discovers the fact that he cannot look upon the individual members making up his crew of workers as so much man power to be handled according to standard procedure as machines are handled. Accordingly the average foreman will be found to be vitally interested in considering in detail all phases of the human-factor side of his job, not only as it affects the handling of his men, but as it applies in his relationship to other foremen and to the management. This is true, even in so-called low-grade industries employing only common laborers, with production under technical control, where the foremen when discussing the "good old days" during which they could knock a man down in order to fire him from the job if he caused trouble, freely state their perplexity at knowing just how to handle the situation at the present time. The comment is even yet heard that "we can't handle men the way we used to do before the war." In the author's opinion it is decidedly to the credit of the American foreman that he is so vitally concerned with improving himself to better manage men, undoubtedly one of the largest unsolved phases of industrial management at the present time.

Conference Use of Analysis

One criticism recently made against the customary use of the conference method in improving foremanship is that its advocates resort to an analysis of responsibilities and duties as a substitute for industrial experience. The charge is rather amusing when one considers the way in which persons advocating and formulating other methods of improving foremanship set themselves up as advisory experts to management, and set forth their own opinions as to just how an "ideal" foreman should conduct himself with the fond idea that their opinions, if followed, will solve all of the problems of industry. The leader of a series of conferences, if he is really competent to handle the method, arrogates to himself no such lofty position. He proceeds on the avowed policy that the foremen in the group are their own best judges as to those responsibilities which they feel can be most profitably discussed with a view to reducing the amount of time required for their satisfactory discharge, or to considering a solution of those difficulties which continually arise in the work of the various departments. He accordingly assists the foremen in the group to diagnose their own troubles and difficulties. This diagnosing is presumably the analysis referred to in the criticism. The absurdity of the criticism may be seen when one realizes that the analyzing is done by the group of experienced foremen themselves, on the basis of their own extensive industrial experience.

The Instructing Responsibility

Another criticism which has been advanced with some justification in certain instances has dealt with the seeming overemphasis in the case of certain conferences upon the topic of "The Foreman as an Instructor or Teacher." It is quite true that the average foreman does not consciously recognize the fact that he has any responsibility for instructing any one in his department. With one exception, the author has never had a group of foremen bring out a teaching or instructing responsibility, in making a preliminary analysis of their own jobs. The one exception occurred in the case of foremen from an industry with a very high labor turnover and no training department. In this particular case, the breaking in of green help loomed large in the minds of the foremen. However, it has been the invariable experience of those conducting foremanship conferences that, even in the case of foremen who are at first entirely unconscious of any responsibility for instructing their help, following the discussion of such a topic as that of reducing carelessness on the job, it suddenly dawns upon the foremen that a large part of the trouble encountered under this heading is due to the fact that they have not taken the trouble to properly instruct or teach their men. Their interest in the subject is then high, and it is accordingly discussed from various angles. It is quite true that the conditions of industry do force a foreman to use practical rule-of-thumb methods of instructing which will bring results after a fashion, when he does feel called upon to give instruction to some one, yet the average foreman will voluntarily want to go at some length into the subject when it comes up. The author does not know of a case within his own experience or those of associates engaged in conducting conferences with foremen, where the topic of breaking in green help and giving incidental instruction to advanced workers has been discussed by the group where the foremen have not afterward expressed their appreciation for having gone into the topic.

Representation of Management in Group

Various questions have been raised from time to time involving the question as to whether direct representatives of the management should participate in a series of conferences with a group of their foremen. Successful conferences have been conducted on numerous occasions where representatives of the management participate. A number of instances could be cited by the author, however, where conferences have been a failure because of the fact that direct representatives of the management were in the group and the foremen accordingly refused to contribute or made certain statements for the benefit of the management which they did not at heart endorse. One of the principal values of the use of the conference method with a group of foremen is the fact that after the foremen enter thoroughly into the spirit of the thing, a number of grievances and grudges are aired to the group and thrashed out by discussion. The mere airing of a considerable proportion of such grievances will lead to an understanding and head off any further bad effect. With members of the management present, however, where such grievances have arisen in the minds of foremen because of some fancied slight on the part of the management, such grievances will not be brought forth, but will remain as festering sores in the minds of the men holding them.

The demand on the part of certain parties to emphasize the necessity for direct representatives of the management participating in the deliberations of a group of foremen is due either to a belief that the conference leader may pick up certain "trade secrets" which he will peddle to other industries, or a knowledge of the fact that the management of the plant itself is bad and they want to head off any chance of discussing in the group any phase of such relationships between the foremen and the management. It should be recognized that much depends upon the individual leader of the conference, as there is a potential danger in permitting a group to get involved in a consideration of the company policies, which consideration may do no good and may only accentuate dissatisfaction. Yet, in a number of cases where a leader has struck some company policy in such a manner as was impossible to dismiss it, he has had a thorough discussion on the matter, and the discussion has resulted in a better understanding between the foremen and management. Certain cases might be cited where a bad policy was remedied by facts brought forth in a discussion with a group of foremen.

Qualifications of Conference Leaders

In the author's opinion the conference method as applied to the improving of foremanship needs no defense or justification. It has proved its value in too many cases to be seriously questioned. It is, however, necessary to emphasize the fact that the success or failure of the use of the conference method depends upon the conference leader. Not only must he be a high-grade man, but a real leader in every sense of the word; he must be absolutely sincere, and the same as he goes from plant to plant, or from industry to industry. The qualifications for conference leaders have been quite well worked out in various publications and will not be touched on further in this paper. It should be pointed out, however, that qualifications other than those which can be set up on paper, to serve as an eliminating screen to keep out the obviously unfit, should be considered. The author has known of cases where persons with training and otherwise quite well qualified to handle the method have failed to register with particular foremen because of personal appearance and dress. Only men with certain qualifications as to experience and training should be secured if a leader is to conduct a real conference and not merely be arbitrator at a series of aimless discussions which "get nowhere."

Various experiences have been secured with reference to the training of conference leaders both by the pick-up method of having the person selected sit in with an experience leader and observe his work and by organized training programs. Sufficient has been done to demonstrate the practicability of giving a training program to a properly selected group of individuals so that they will be able to start in, following such training, and be fairly successful from the start in handling the method with foremen. The demands for training courses of this type have been increasing the past several years, and every indication points to an increasing demand for this type of work to the end that, when need arises in an industry for an application of the conference method to develop intelligent judgment, some one will be available to carry on the work.

In closing, the author would emphasize again that the conference method is not advocated as a universal panacea. It is a method which will work quite effectively under certain circumstances and for certain purposes. Other methods are equally as good, or more efficient under certain circumstances, to accomplish certain purposes. In the author's opinion, however, the conference method as applied to improving foremanship is preeminently valuable in stimulating intelligent active thinking on the part of the foremen on all phases of the world-old problem of handling the human help efficiently and satisfactorily to all concerned, as well as in production problems which cannot be reduced to standard procedure but which must be solved by a consideration of all available factors, resulting in a rational decision or plan.

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Education for Foremanship

By JAMES A. MOYER,[3] BOSTON, MASS.

The trend in industry during the past few years has made foremanship training increasingly important. New types of industrial organization increase the responsibilities of foremen and relieve them of some of the former hit-or-miss routine, thus making them more important in industry. But, at the same time, the absorption of the managing executives in the increasingly acute problems of marketing and sales has had a tendency to sidetrack the foreman. Too frequently, therefore, important decisions affecting the work of the foremen and the men under them have been made over the foremen's heads or behind their backs. Under these conditions a special training of the foremen is important that they may understand and appreciate the real aims of the management in production methods, personnel relations, and similar activities, and that they may properly understand and present to the management their own particular problems and needs.

That the importance of training is being realized is indicated by the fact that the number of foreman-training courses in the United States has increased several hundred per cent in a year's time. In most cases the need of the course was determined after just as careful study and planning as in any other phase of manufacturing. There is also a strong tendency to place the course on a permanent and organized basis. In 1926 there were 324 such courses reported to the United States Chamber of Commerce.

In the supervision of employees in industry that is fundamentally necessary, the foreman stands as the intermediary between the men and the management. In spite of the fact that auxiliary agencies for supervising and planning that have grown up, seldom permit the foreman to shoulder all of the responsibilities which go with the job of supervising employees, the foreman is one of the most valuable assets which industry has. The old type of driving foreman has gone. The new type of foreman—a leader of men—will come as fast as the management is willing to train him. Any plan which will help him to utilize his abilities to the utmost is a factor in management that cannot be neglected. It is for this purpose that the training course is valuable.

The foreman of today must be a potential executive and have the idea of what an executive is. Hugo Diemer, in his book "Foremanship Training," summarizes the needs of training by saying that the foreman must be taught how to get results by the use of his men and materials; how to plan; how to use his head instead of his muscles; and how to get his men to work willingly and enthusiastically.

The aim of the well-conducted course is to accomplish this purpose. It will also apply constructive thinking to specific problems. It helps the members of the group to organize the trade knowledge and experience which they may have, and to practice it in the solution of problems which may arise in regard to their jobs and their responsibilities. Not only will it aid the present or prospective foreman to discharge the responsibilities of his position effectively, but it can be made to make his responsibilities familiar to others, even the higher supervisory staff, and produce a more harmonious and effective organization.

A careful analysis of a number of successful foreman-training courses shows that the work depends upon a number of factors, namely, (1) the attitude of the management; (2) the character of the group; (3) the subject-matter of the course; (4) the ability of the instructor, leader, or chairman; (5) the type of instruction; and (6) the conditions under which the training is given.

[3] Director, State Department of University Extension; President National University Extension Association. Mem. A.S.M.E.

Attitude of Management

Foreman training must be initiated, supported, and followed by the management through the personal attention of some one who possesses not only initiative but tenacity of purpose. The results will be in direct proportion to the extent to which the management cooperates. It cannot be carried out in an atmosphere of uncertainty, doubt, suspicion, and unwillingness. The very nature of the class or group meetings demands an open discussion of actual plant problems, and may well involve the company policies.

The first effort of the management must be to see that the foremen themselves realize the need for it. This requires a full explanation of the purposes and advantages of the project. Such an explanation is really a selling plan and should be prepared just as carefully as any selling plan. The result of forcing training upon men who are hostile to the plan is usually disastrous.

What actual part the management should take in the work of the course is always a problem. Outstanding results have been accomplished in some instances where company officials took part regularly in the program. Where this is not the case there is apt to be a feeling expressed that conditions in the plant would be different if the officials could hear some of the discussions. On the other hand, where some representative of the management sits in on the course the foremen are apt to talk as they think the management would like to have them, and not as they talk among themselves. One good way of dealing with the problem is to have meetings occasionally which the superintendents and other executives may attend.

A good method of securing the foreman's interest is by calling a voluntary meeting to explain the plan and then follow this up by individual interviews, giving a comprehensive tentative outline of the topics to be considered, and, if the lecture discussion method is to be used, the procedure should be explained. The foreman's pride in his job should be recognized and used in obtaining his cooperation.

Best results can only be secured where the members of the group have approximately the same rank. As the attendance of higher executives is apt to prevent full and free discussion by the foremen, so if assistant or prospective foremen are present they hesitate to express their opinions freely before actual foremen.

Topics for Study and Discussion

No hard-and-fast rule can be given as to the subjects to be discussed. There can be no standard procedure for instruction. Successful results have been secured through the use of all sorts of courses under varying conditions, the success depending upon the degree to which the course met the existing needs.

The essential thing is to assist the foreman to organize his knowledge and experience so as to use it to the utmost and to give him a picture of his responsibilities and his possible contribution to the efforts of the organization. The course should be such as to develop him in his present job as well as be informative. As the average foreman is not given to discussion of his problems the effort should be made to arouse and carry onward discussion of mutual problems, and the group should be trained to speak clearly on their feet in order that they may not only carry on the class discussions but be better trained to engage in the actual conferences needed in general business operation. Elementary management principles should be combined with pro-

duction policies and methods of leadership as an important part of the course.

Any text material which is used for home study should be simple and especially prepared to meet local needs. It should serve to acquaint the individual with the general principles which apply. The application of these principles to the particular problems can then be brought out in group discussion. Without these general principles it has been found the foremen cannot contribute much to the discussion.

If the management will see that the foremen are educated to appreciate that their service to the employer in producing at minimum cost will make for increased production, higher wages, and general industrial efficiency, the result will be that the foremen will no longer look at their industry as a device merely for reaping profits for the owner.

Methods of Instruction

The conference and discussion method as compared with the straight lecture is far more stimulating, because it encourages active thinking on the part of the individual. The faculty of constructive thinking is far more valuable than mere knowledge. As far as possible, the topics of discussion should be arranged and grouped so that there is a logical progression of thought throughout the course. The discussion at a class or group meeting should aim to give emphasis and significance to *one particular idea*. This may be approached from several viewpoints in order that it may connect with the self-interest of each member of the group.

Some topics for discussion which can be handled with profit are job analysis, plant-organization relationships, interest in the job, keeping up production, lowering costs, laying out work, distribution of supervision, carelessness on the job, leadership, making reports, records, apprentice training, cooperation.[4] It is obvious that the discussion method of instruction could not be used with such topics as wage policy, selling, costs, and marketing; not at least until a considerable amount of direct information had been given to the group by some executive of the company. Again, the handling of such topics as the administration of first aid and the training of workers, involves ability to perform, and requires preliminary instruction before any discussion is of value.

The Instructor or Class Leader

It is no easy matter to secure a satisfactory instructor, or leader, or chairman for class meetings or group conferences of foremen. The instructor has before him a difficult job of teaching. His success depends largely upon the degree to which he can function as a teacher, without using ordinary class or lecture procedure.

Foremanship instruction may be made available through the State Department of Vocational Education, just as instruction is available in the vocations which may be authorized by state laws. All of the states and the territory of Hawaii take advantage of the distributions of Federal funds under the Smith-Hughes Act, which provides that for every dollar spent (by the Federal Government) the state, local community, or both, shall expend an equal amount.

Assistance in carrying on a foreman-training activity may usually be obtained from such institutions as state university extension, state vocational education, local manufacturers' associations, state manufacturers' associations, trade associations, and private agencies.

The Manufacturing Department of the Chamber of Commerce of the United States has published in its bulletin entitled "Foremanship" a precise but comprehensive statement of the several plans by which foreman training may be organized.

Working Conditions

The only requirements for a meeting room are enough space, suitable light, heat, ventilation, chairs, a fairly large blackboard, and some arrangement to allow the men to take notes. The time may range from a two-weeks' conference with all-day sessions down to weekly hour meetings or a monthly meeting of three or more hours. The meetings may be held on the company's time, the men's time, or upon some combination plan. But as experience has shown that many advantages come from discussion of current plant problems and these are always present, a continuous program of conferences is most desirable.

Conclusion

Although some of the results of foreman-training work can be measured statistically, the more important and valuable ones are intangible. The experience of many industries has shown as a result a noticeable improvement in morale, production, costs, and labor turnover. If this improvement represents even a small percentage in each factor, the total savings are far greater than the expense.

The rapid growth and permanent status of foreman training is due to the fact that it is one solution to the problem of increasing the morale of men as individuals and as members of a manufacturing organization. It gives the foreman a definite point of view regarding company policies, produces a better understanding of responsibilities, increases both vertical and horizontal cooperation, and stimulates thought and discussion along lines not covered in every-day practice.

Discussion

A WRITTEN discussion was submitted by Montague A. Clark[5] in which he stressed the importance of the foreman as the real manager of many enterprises because vast expansion of industry had removed the major executives a great physical distance from control. The result was the necessity for more careful selection and training of the minor executives, such as foremen. The educational development of the operative forces required the foreman to keep in step with the advancing intelligence of the force under him. He pointed out that stability of the working force came more through liking of the job than through increased remuneration, and that to like the job the workman must usually like the foreman, and would do so if the foreman was a leader.

Mr. Clark enthusiastically endorsed the conference method as training the men in the essentials of analysis and clear thought, and insisted that the management must be "sold" on the idea and give the foreman the opportunity to discuss any phase of the industry with which he was concerned. He expressed the feeling that experience had demonstrated that there would be no haphazardness, as the group would instinctively raise the problem of most importance and those of lesser importance in the order of their relative value. He disagreed with the authors of the papers by saying that matter could be profitably prepared in advance and used to supplement the discussions, taking up first the immediate plant problems, then the company's policies, and finally the pre-

[4] References to adequate subject-matter for conferences may be found in such books as "Foremanship Training," by Diemer, and "Foremanship and Supervision," by Cushman; books on foremanship by the Chamber of Commerce of the United States of America. "Practical Foremanship," by G. L. Gardiner, and current publications of the Federal Board for Vocational Education, Washington, D. C., have some interesting subject-matter.

[5] Educational Secretary, The Open Shop Conference of Connecticut, Inc., Meriden, Conn.

pared material. He did not favor training in public speaking, as it was too apt to be overdone by some. In his view the success of the method depended on the leader first, then on the company attitude, then on the conditions, and finally on the group equality of rank. He expressed the opinion that the meetings would be most successful if held away from the plant activities, and pointed out that the results would not come quickly and that the method should be adopted as a permanent policy.

Carl F. Dietz[6] stressed the importance of a full and free discussion. He wrote that his own experience with the Connecticut plan, first tried in his own organization, had been successful. Its fundamental characteristics, he explained, were the provision of grouping men according to definite levels, excluding superiors, and being without a formulated predetermined text. It not only permitted but encouraged the conference to enter into free constructive discussion of any subject the leader desired. He emphasized the importance of the leader and his necessary qualifications.

N. C. Miller[7] wrote that Rutgers University had found that, contrary to common belief, a great many foremen were interested in educational courses more than in vocational ones, and they would enroll for and follow with interest such subjects as economics and psychology if given in a reasonably practical way; and that the Extension Division was gradually eliminating the vocational tone from all its foremanship work and substituting educational work.

Frederick J. Trinder,[8] in a written discussion, brought out the experience of the State Board of Education of Connecticut in adopting the Connecticut plan, and what was being done to help train leaders. This the board felt was properly the function of the educational department. He urged the adoption of the conference plan and presented outlines and letters that the board had sent out to manufacturers in explanation of its programs.

R. H. Spahr[9] added to the figures presented by Mr. Moyer by giving complete reports on Massachusetts and Connecticut for 1926 showing an increase for Massachusetts of from 26 courses to 62 and for Connecticut from 3 to 46. He wrote of the importance of having continuity of foremanship instruction year after year, and that the company wanted continuing results. Courses completed in one year left much to be desired. He insisted that courses running from three to five years were more desirable, but that some of the standard prepared courses did not make this possible. He agreed with the authors that no style, type, or method of improving industrial foremanship had a divine monopoly as concerned the success of the work.

Hugo Diemer[10] pointed out the kind of knowledge that the foreman needed to fill the position as leader and which he could not acquire readily in his industrial progress up to the position of foreman, such as how to understand and handle men, how to make best use of stock room and tool room, what cost control meant; how he could help to get true costs and how to use the cost data; how to organize his work; the advantages of centralized employment; the reasons for various systems of wage payment, and what was meant by industrial relations and industrial-service programs.

He pointed out that the foreman needed to know more about the executive phases of his job, and that proper courses "sold" him on the advantages of scientific vs. rule-of-thumb methods, of harmony and cooperation vs. discord, of maximum output vs. restriction of output, and of developing each man to his greatest efficiency. He declared that no course aiming to deal with fundamentals could be expected to treat of the processes of a given industry. Foremanship training aimed to do the groundwork, to build the foundation. All production rested on certain basic principles of management which the foreman should study and understand.

J. O. Keller[11] heartily endorsed Mr. Moyer's views regarding the attitude of the management, the need of the proper leader, and the fact that no standard of proceeding for instruction was possible. But he insisted that the lecture method had a very real use and would also produce the proper discussion and cause the foremen to think. He wrote that the Pennsylvania State College was this year starting a foreman's course to teach the manufacture of steel from a technical standpoint.

James W. Hook[12] took distinct exception to the view that foremen could not be trained by their superiors. He expressed the opinion that if this were the case then the foreman would be equally unable to train the men under him. He felt that one of the principal reasons for this movement to train foremen was to make them understand the modern thought in industry—that foremen themselves were a part and parcel of management. If they realized this they would gladly express themselves. In his view, if a foreman was unwilling to express his real views, after having been asked to do so by his superiors, then there must be something wrong or insincere with the superior, or the foreman was not of the proper caliber. He expressed the opinion that superior officers did not talk enough with the foremen nor get close enough to them. If it was a problem today to get foremen who would speak their minds freely, then we had better get busy and make and educate foremen who would.

Glenn L. Gardiner[13] expressed the opinion that the average foreman was more likely to fail from lack of information than from lack of ability. That unless his own experience was broadened by some educational method, he was apt to reach conclusions based entirely on his own limited experience. After pointing out the importance of foremen in industry, he insisted that a good training course must give the foremen the essential information and principles to manage their department, teach them to think and apply the information and principles, and stimulate them to be constantly alert to the possibilities of their jobs and interested in their own self-development.

He stressed the importance in securing such a course of having text material, plainly and interestingly written, and in proper form for easy distribution and handling; regular discussion periods for the interchange of ideas as to plant problems and policies, the text material, or information that the management desired to convey to the men; and where the foreman could have a chance to get better acquainted, check up on the accuracy of their opinions, and learn to express themselves and bring up matters which should have the management's consideration. He felt that the proper stimulus could be given by having interesting meetings with the cooperation of the executives and by having an occasional outside speaker to bring the men abreast of new ideas found practical in other progressive concerns. A practical course must develop better foremen, train prospective foremen, develop leadership, deepen the channels of cooperation and understanding, and represent management to the foremen so that they could represent management to the men.

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[8] State Director of Vocational Education, Hartford, Conn. Mem. A.S.M.E.

[9] In Charge Employer-Employee Relations Service, Chamber of Commerce of the United States, Washington, D. C.

[10] Director of Industrial Department, La Salle Extension University, Chicago, Ill. Mem. A.S.M.E.

[11] Head, Department of Engineering Extension, Pennsylvania State College, State College, Pa. Mem. A.S.M.E.

[12] President, The Geometric Tool Co., New Haven, Conn. Assoc-Mem. A.S.M.E.

[13] Editor, *The Industrial Executive*, New York, N. Y.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

Binary Mixtures in Steam Engineering

CONTRARY to what happens in the case of such simple substances as water when subjected to the action of temperature and pressure, mixtures of two substances, particularly those having different boiling temperatures, behave in a manner substantially such as shown in Fig. 1. Here two substances A and B are employed having respective boiling points t_A and t_B (assuming the same pressure p). The abscissas are parts by weight ξ of substance B in the mixture. If G_A and G_B are respectively the weights of the constituent parts, then

$$\xi = \frac{G_B}{G_A + G_B} \qquad [1]$$

In this case only those mixtures are considered whose boiling-point curves contain no maximum or minimum values, which means that the boiling temperatures lie all the time between the boiling points t_A and t_B of the pure constituents of the mixture. The vapor produced from such a boiling liquid and remaining in equilibrium with it then always contains a majority

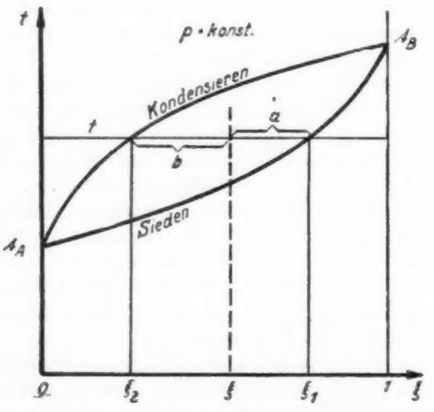


Fig. 1 Curves of Boiling and Liquefaction Temperatures of a Binary Mixture
(*Kondensieren* = condensation; *sieden* = boiling.)

of the constituent having the lower boiling point, which is A in Fig. 1. A line was therefore plotted in Fig. 1 showing the variation of temperature as a function of the composition of the vapor. Should a vapor mixture of the composition ξ_2 be cooled down to that line (temperature t), condensation will begin with any further withdrawal of heat, and the liquid produced by this condensation will have the composition ξ_1 indicated by the boiling curve.

In the present article the author uses the subscript 1 to indicate the liquid, and subscript 2 the vapor, phase. The points above the condensation curve indicate superheated steam and those below the boiling curve the part of the liquid not boiling. Between the two curves the mixture consists of liquid and vapor constituents of various compositions. In a mixture of average composition ξ at pressure p and temperature t, the liquid part (F) and the vapor part (D) are in the ratio $\frac{F}{D} = \frac{b}{a} = \frac{\xi - \xi_2}{\xi_1 - \xi}$. With increase in pressure the curves of boiling and condensation temperatures move upward in accordance with the vapor tensions of the constituent parts.

Liquefaction and Absorption

Let it be assumed that in a closed container there is a liquid mixture of composition ξ_1 and temperature t. There will then be found in a state of equilibrium above the liquid some vapor of

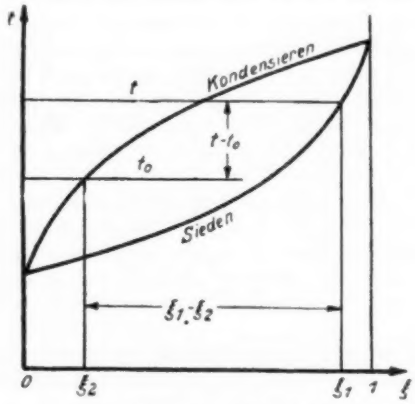


Fig. 2 Absorption Process
(*Kondensieren* = condensation; *sieden* = boiling.)

temperature t and composition ξ_2 (Fig. 1) and the proper saturation pressure p. If now heat be abstracted from the container the pressure will fall as a result of the reduction of temperature, and condensation of a part of the vapor will take place. If the container be in communication with another vessel containing a vapor mixture at the same pressure, vapor will flow from the second container into the first and be condensed in the latter as long as heat continues to be abstracted from the first container. This will occur also if the vapor flowing over is of the same pressure but of a lower temperature, and also if it has a different composition from that of the liquid in the first container. The heat of liquefaction of the vapor temperature t_0 may therefore be available at a higher temperature, Fig. 2.

It is usual to describe such a precipitation of a vapor mixture of a certain composition into a solution of a different composition as absorption of the vapor by the liquid. The heat evolved during this process is different from the heats of vaporization of the constituents of the vapor mixture, and is as a rule greater, due to the added effect of evolution of the heat of mixture and heat of solution. For the technical application of the process it is necessary that the absorption should occur with sufficient rapidity, and this may be accelerated by the employment of large surfaces (stepped flow, spraying, trickling, etc.) and vigorous intermingling of the liquid and the vapor. The absorption is controlled by the same laws as the transfer of heat.

A familiar instance of the employment of absorption is the absorption refrigerating machine. In dealing with large temperature differences it is necessary to have the composition of

the liquid ξ_1 and that the vapor ξ_2 as different as possible. Since the vapor is always formed out of the liquid, the best mixtures for the purpose are those in which the vapor, which in accordance with Fig. 1 is in equilibrium with the liquid, has a composition widely different from that of the liquid.

The mixtures which behave best in this respect are those consisting of "non-vaporable" materials dissolved in a liquid. In such a case no matter what the composition of the liquid is, the vapor above the liquid may consist only of the solvent, since the solute does not develop any vapor, which means that regardless of what the composition ξ_1 of the liquid may be, ξ_2 is always equal to zero. In the t-ξ diagram the condensation line therefore always coincides with the axis of ordinates. The boiling temperature of such a mixture is always higher than that of the solvent at the same pressure, and if the solvent is water the solution produces superheated steam.

In refrigeration such aqueous solutions are not usable as their boiling temperature falls below the temperature of the ambient medium only at extremely low pressures. On the other hand,

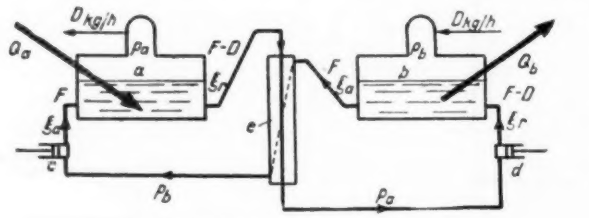


FIG. 3 CYCLE OF SOLUTION PROCESS
(*a*, solution boiler or evaporator; *b*, mixer or absorber; *c*, pump; *d*, motor or throttle valve.)

such solutions are eminently suitable for use at higher temperatures, particularly as water vapor is one of the best-known working mediums of engineering. They may be applied in two ways. In the first place in cyclic processes wherein the waste heat in low-pressure steam which otherwise would not be usefully employed, becomes available for use at a higher temperature (heat pump, steam-pressure transformer).[1]

In another direction these processes through raising the boiling temperature by additions of heat make it possible to obtain steam of very high temperature and yet moderate pressure (improvement of working processes in the steam engine without increasing the steam pressure. Compare the article by B. Oetken on Steam Transformation in *Archiv für Wärmewirtschaft*, vol. 6, 1925, p. 303.

CYCLIC PROCESS OF THE SOLUTION

Fig. 3 shows the cycle of such a process. The solution is first led through an evaporator *a* and an absorber or mixer *b*. In the evaporator the pressure is p_a and in the absorber p_b. A pump *c* forces the solution from *b* to *a*, and a part of the work of the pump can be recovered in a motor *d*, but with the pressures and amounts of liquid employed in practical applications of the process the power consumed by the pump is so small as compared with the rest of the energy employed that it may be completely neglected, and the motor *d* may be replaced by a simple throttling valve.

Assume that the evaporator handles *F* kg. of liquid per hour of a composition ξ_a (weak solution) and temperature t_{a1}. By supplying to it a quantity of heat Q_a there will be produced *D* kg. of vapor per hour at a pressure p_a, whereby the composition of the solution will be changed to ξ_r (strong solution) and its quantity to $(F - D)$ kg. per hour. The temperature of the vapor thus produced corresponds at each point of the evaporator to the boiling temperature of the solution. By proper handling of the vapor and solution in the evaporator (rectification) it is possible to arrive at a condition where the steam escapes from the evaporator with the highest temperature prevailing therein, i.e., the boiling temperature t_{a2} of the strong solution. This solution reaches the mixer through the throttling valve *d* with a temperature t_{b1}. The mixer also receives, however, *D* kg. of the exhaust steam per hour so that the solution attains again the composition ξ_a and quantity *F* kg. per hour. But in order to condense this exhaust steam (absorption) it is necessary to withdraw from the mixer Q_b kilogram-calories per hour. The temperature in the mixer is given by the boiling curve of the solution at pressure p_b (pressure of exhaust steam). The solution leaves the mixer with the temperature t_{b2} which is the boiling temperature at composition ξ_a, and is returned to the evaporator by pump *c*. Here it must be heated again to the boiling temperature at pressure p_a before evaporation begins anew.

On the other hand, the liquid carried over from the evaporator to the mixer must be cooled down in the latter to the boiling temperature. This requires a certain consumption of heat which flows from the evaporator to the mixer to no purpose (irreversibly). As in the case of absorption refrigerating machines, this loss can be reduced by having the hot solution coming from the evaporator flow in counter current (as in the heat exchanger *e*) to the liquid coming from the mixer. As the cold weak solution is greater in amount by *D* kg. and as the weak and strong solutions have the same specific heats, it is possible not only to cool the strong solution to the mixer temperature, but to heat simultaneously the weak solution up to the boiling temperature in the evaporator.

The cycle described is that of a thermal compressor in which the vapor is compressed from pressure p_b to pressure p_a of the evaporator, and wherein furthermore no mechanical work is expended but a certain amount of heat is carried from the evaporator temperature to a lower temperature. Taking the case of an absorption refrigerating machine, the cycle comprising generator, absorber, heat exchanger, and circulating pump corresponds exactly to the mechanical compressor of the compression refrigerating machine. (Reference is here made to a paper by Altenkirch on "Reversible Absorption Machines." Compare *Journal of the* A.S.M.E., vol. 36, March, 1914, Foreign Review Section, p. 553.)

TECHNICAL APPLICATIONS

Such a thermal compressor seems at first particularly adaptable to such purposes in steam engineering as those where hitherto mechanical compressors or jet pumps have been employed (heat pumps, pressure evaporation, steam-pressure transformation).

If the exhaust heat Q_b is used to produce steam of a pressure higher than that of the exhaust steam, p_b, then the mixer may be considered as a device which converts the exhaust steam otherwise not utilizable into a steam of higher pressure and hence higher temperature. By selecting a proper composition on the boiling curve it becomes possible to arrive at a condition where the steam produced with the mixer heat Q_b has the same pressure p_a as the steam produced in the evaporator. This will make it possible to mix and employ simultaneously these two kinds of steam.

Figs. 4 and 5 show diagrammatically such installations and correspond essentially to the designs proposed by Stender

[1] Recently in refrigerating machines use has been made of solutions of non-vaporable calcium chloride as described by Planck in an article on household refrigerating machines in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 71, 1927, p. 1436: the "Sicfrigo" refrigerating machine. The fact that the "solution" at the temperatures employed is not a liquid but a solid does not affect the fundamental principles.

(*Zeitschrift des Vereines deutscher Ingenieure*, vol. 71, 1927, p. 830 and *Archiv für Wärmewirtschaft*, vol. 8, 1927, p. 233). Fig. 4 shows a "single vapor" unit with utilization of process (*Brüden*) steam (compression evaporation). Here the generator *d*, which is of the multiple-stage type, is heated by steam having a pressure p_a, while the process steam has a pressure p_b. In the boiler *c* heated by the mixer heat G_b, φD kg. of steam are generated per hour, and in the evaporator *D* kg. of steam per hour, and in this a quantity of heat Q_a is used. Both kinds of steam are then mixed together and used to heat the generator *d* in which *D* kg. of process steam are produced per hour, this steam going then to the mixer *b*. Generally the amount of heating steam produced is $(1 + \varphi)$ *D* kg. per hr. too much. No waste heat is produced at the temperature of the process steam, but a certain excess of heating steam of pressure p_a is available. If there is no way to utilize this steam otherwise, then not all the process steam is conveyed to the mixer but only so much as is necessary to produce exactly the required amount of heating steam, while the rest is permitted to escape as exhaust steam.

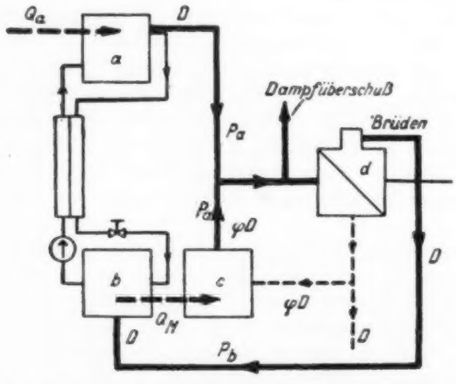


Fig. 4 Single-Vapor Plant with Utilization of Process Steam

(*Brüden* = process steam; *dampfüberschuss* = excess steam.)

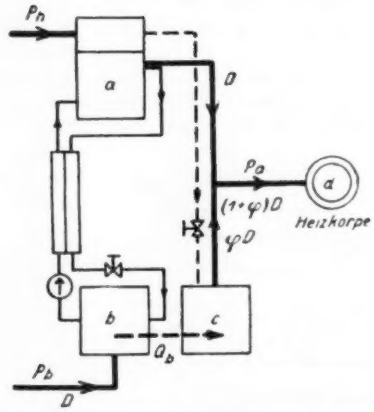


Fig. 5 Production of Heating Steam of Medium Pressure

(*Heizkörpe* = heating unit.)

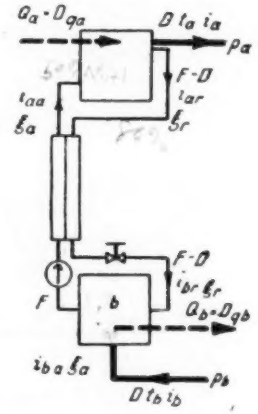


Fig. 6 Diagram for Determination of Material and Heat Balances

Fig. 5 corresponds to a heating unit *d* which consumes steam of pressure p_a, whereas the plant produces only steam of a higher pressure p_h and a lower pressure p_b. In this case the high-pressure steam is used to heat the evaporator *a* (Q_a), and the low-pressure steam in the mixer *b*. The solution is so selected that the temperature in the mixer is sufficiently high in order to produce in the boiler *c* steam of the same pressure p_a. The conversion of the high-pressure steam into steam of the pressure required occurs therefore not through irreversible throttling, but in the manner at least partly reversible, namely, in a way wherein a certain part of the low-pressure steam is compressed to the required pressure, the result of which is that a smaller amount of high-pressure steam is needed to cover the steam requirements. The whole process may be considered as a reversible mixing of the high- and low-pressure steam so as to produce steam at a pressure lying between the two.

It is the author's belief that cyclic processes involving binary mixtures may have great economic significance when applied to steam engines. Cyclic processes used for the generation of energy are all the more valuable from a thermal point of view the higher the temperature is at which heat is supplied. In the case of the ordinary steam engine this temperature is essentially the temperature of evaporation and therefore is a function of the boiler pressure. The effort to produce higher efficiency leads to an increase in the boiler pressure, but even at the highest technically permissible pressures the evaporation temperature (310 deg. cent. or 590 deg. fahr. at 100 atmos. abs. pressure) is still far below the limit permissible by the strength of the materials employed (approximately 450 deg. cent. or 842 deg. fahr.). The upper part of this available temperature range, i.e., somewhere between 450 and 250 deg. cent. or (842 and 482 deg. fahr.) can be utilized in the case of a steam engine only by interposing some cyclic process which takes place between the temperatures indicated above. It would appear reasonable to employ for this purpose a vapor other than steam and one whose pressures in that temperature range are technically acceptable. This leads to the employment of binary-vapor engines, wherein, for example, mercury is used in the upper temperature range and water in the lower. (*Zeitschrift des Vereines deutscher Ingenieure*, vol. 68, 1924, p. 834, and vol. 71, 1927, p. 189.)

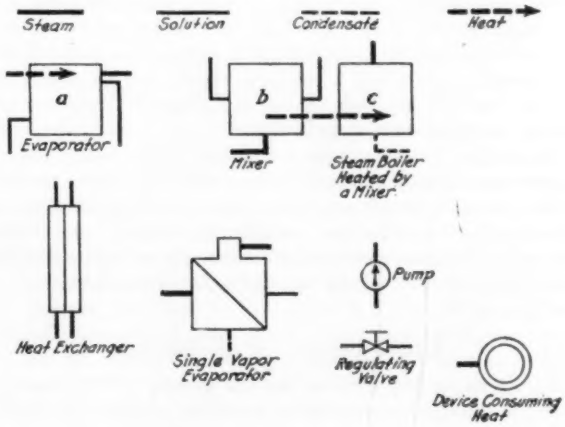


Fig. 6a Notation for Figs. 4 to 6

The same end can be attained by using a solution as the working medium. The heat is supplied to the evaporator at the highest permissible temperature (about 450 deg. cent. or 842 deg. fahr.), while the heat in the mixer is liberated at a temperature which is suitable as the upper range for the cyclic process in a conventional steam engine. The engine generated in the evaporator then performs work in a steam engine against the mixer pressure and is afterward exhausted to the mixer.

Externally this arrangement corresponds to a conventional steam engine except that instead of a steam boiler an evaporator is installed, the mixer takes the place of the condenser, and the feed pump is supplanted by a circulating pump. The only additional element is the return flow of the solution through the throttling valve. The difference between the two processes

is that in the boiler the water is evaporated completely and this evaporation occurs at a constant temperature, while the evaporation from the solution is only partial and takes place at rising temperature.

Since the boiling pressure of a strong solution at a given temperature is much lower than the pressure of pure water even with the highest permissible temperatures in the evaporator, the pressures used are such as can be quite easily handled (15 to 20 atmos. abs.). One and the same steam engine working between pressures p_a and p_b can take the steam either from a conventional steam boiler or from an evaporator operating on a solution. In the first case the exhaust goes into the condenser

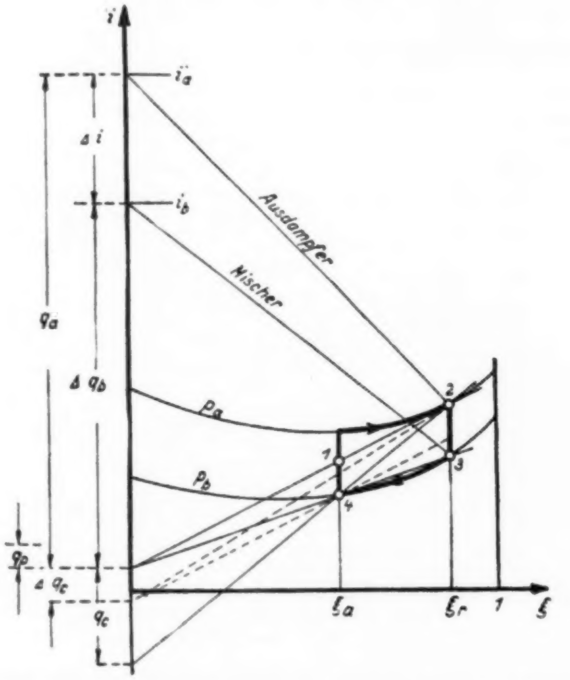


Fig. 7 Complete Cyclic Process of a Solution Between Evaporator and Mixer
(*Ausdampfer* = evaporator; *Mischer* = mixer.)

and in the second into the mixer. The same quantity of steam is used in both cases for the same output.

Thermodynamically the two processes differ only through the fact that the used-up temperature head between the source of heat supply (steam boiler or evaporator) and heat exit (condenser or mixer) is greater when a solution is used. The conventional steam-engine process may be referred to as the lower limit attained with an infinitely diluted solution.

Computation of Binary-Mixture Cyclic Processes

The author claims that the numerical methods of handling the cyclic processes dealing with the solution are substantially the same in all cases. The only things that have to be considered are the relations existing between the quantities and compositions of the vapor and liquid, temperatures, pressures, and quantities of heat involved. From diagram of Fig. 6 the author obtains the following formulas.

1 *The Material Balance.* The solute substance being nonvaporable at the prevailing temperatures, it is found only in the liquid form and its quantity remains therefore unchanged. In both evaporator and mixer, therefore,

$$\xi_a F = \xi_r (F - D)$$

This determines the specific amount of the solution

$$\lambda = \frac{F}{D} = \frac{\xi_r}{\xi_r - \xi_a}$$

2 *The Heat Balance.* Let Q denote the amount of heat either generated or absorbed per hour and q the amount of heat per kilogram. Then for the total plant,

$$Dq_a + D\, i_b = D\, q_b + Di_a$$

or

$$q_a - q_b = i_a - i_b \quad\text{[2]}$$

The heat of vaporization q_a here includes the work of the circulating pump q_b, which latter may, however, be neglected.

For the evaporator,

$$Dq_a + F\, i_{aa} = (F - D)\, i_{ar} + D\, i_a$$

or

$$q_a = i_a - i_{ar} + \frac{F}{D}\,(i_{ar} - i_{aa}) \quad\text{[3]}$$

For the mixer,

$$Dq_b + Fi_{ba} = (F - D)\, i_{br} + Di_b$$

or

$$q_b = i_b - i_{br} + \frac{F}{D}\,(i_{br} - i_{ba}) \quad\text{[4]}$$

The author gives a diagram which makes all of these relations clear and shows the heat content of the solution and vapor as functions of the composition ξ. Fig. 7 shows the complete cycle of a solution between evaporator and mixer; 1–2 is the process in the evaporator, 3–4 that in the mixer, and 2–3 and 4–1 the processes in the heat exchanger, where the quantity of heat

$$Q_c = D\, q_c = F\,(i_{aa} - i_{ba}) = (F - D)\,(i_{ar} - i_{br})$$

is transferred, and hence

$$\frac{i_{ar} - i_{br}}{i_{aa} - i_{ba}} = \frac{F - D}{F} \quad\text{[5]}$$

which shows that the lines 1–2 and 3–4 produced must intersect at the axis of ordinates. All the amounts of energy herein considered when referred to 1 kg. of vapor appear as intercepts on the axis of ordinates, and thereby make it easy to see the influence of each of the variables. Thus, $\Delta i = q_a - q_b$ is the increase in the heat content of the compressed steam as the result of the action of the thermal compressor. If the process is used for generation of energy then Δi is the work generated in the steam engine and is equivalent to the adiabatic heat drop in an engine free from losses. If there were no heat exchange then 1 would fall on 4 and 3 on 2. Because of this the line 2–4 cuts off the axis of ordinates the heat q_c exchanged per 1 kg. of steam. Should the heat exchanger be left out, $q_a - q_b$ will become greater by that amount, without, however, any improvement in the effective output Δi. The broken straight lines correspond to an imperfect heat exchanger having a loss of the value Δq_c.

Knowing the shape of the boiling curves in the i-ξ diagram and the temperature of the steam generated, i.e., the boiling temperature of the solution, all the necessary magnitudes and the influence of their variation can be read off from the i-ξ diagram.

i-ξ Diagram for Potash Solution

It would appear that from the point of view of the processes discussed above, solutions of potassium hydroxide (KOH) and sodium hydroxide (NaOH) in water are particularly suitable.

The data for the computation of the i-ξ diagram for a potash solution are as yet very incomplete, and practically all investigations known are limited to what happens at pressure of 1 atmos. (760 mm. of mercury). However, by means of certain physical laws it becomes possible to gain a fairly clear picture of the properties of the solutions, even though numerically it may not be entirely precise. We know the process of boiling of a potash solution at a pressure of 760 mm. of mercury in its functional relation to its composition. By using Dühring's rule [Müller-Pouillet, "Textbook of Physics" (in German), edition 1926, vol. 3, p. 481], which, however, is only approximately correct, it is possible to draw conclusions as to the boiling of the liquid at other pressures. According to this rule, for a given composition ξ the relation between the absolute boiling temperature T_L and the boiling temperature T_W of pure water ($\xi = 0$) is independent of pressure and is therefore exclusively a function of the composition.

$$\frac{T_L}{T_W} = K = f(\xi) \qquad [6]$$

If, therefore, we know the boiling temperature of a solution at some pressure, for example, 760 mm. of mercury, it becomes possible to determine its behavior at any other pressure from the tension curve of water vapor (Fig. 8). For pressures which are not very high the diagram is fairly reliable, but at higher pressures one should expect to encounter material deviations.

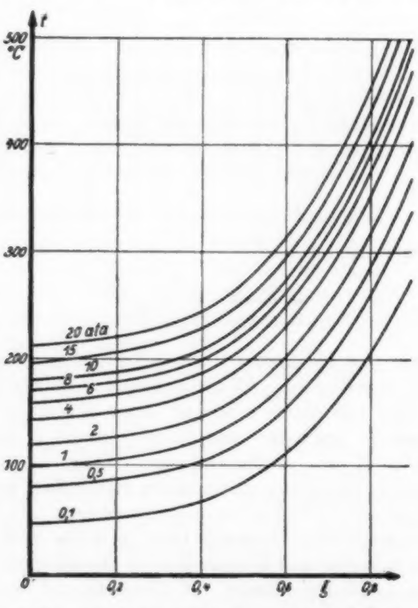


FIG. 8 TEMPERATURE OF BOILING POTASH SOLUTION

The differential heat of evaporation q_d can be computed from the Clapeyron-Clausius equation.

$$q_d = A\,(v_2 - v_1)\,T_L\,\frac{dP}{dT_L}$$

where A is the mechanical equivalent of heat in kilogram-calories per meter-kilogram, (1/427); v_2 is the specific volume of superheated steam at P and T_L in cubic meters per kilogram; v_1 is the specific volume of the fluid solution at P, T_L, and ξ; and P is the pressure in kilograms per square meter. If the specific volumes of the steam and the liquid and the differential quotient dP/dT of the tension curve of the solution for a given composition is known, it becomes possible to compute q_d. As the specific volume of superheated steam is known and the specific volume of the liquid may be neglected in the first approximation, the mere knowledge of the tension curves for various compositions simplifies greatly the computation. Such curves can be very easily plotted as they do not involve any measurement of heat quantities.

For pure water the differential heat of vaporization q_d is the well-known heat of vaporization r. Taking the specific volume of boiling water as v'' we have the Clapeyron-Clausius equation as follows:

$$r = A\,(v'' - v')\,T_W\,\frac{dP}{dT_W}$$

Assuming now with Dühring that

$$T_L = KT_W \text{ and } \frac{dP}{dT_L} = \frac{1}{K} \times \frac{dP}{dT_W}$$

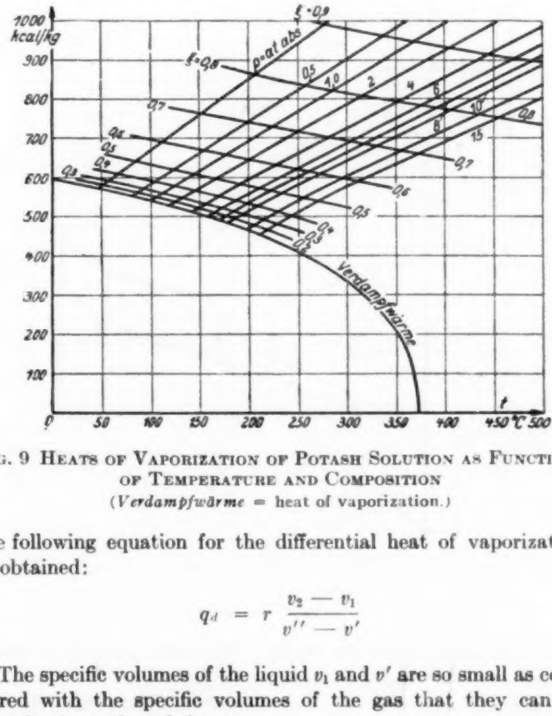


FIG. 9 HEATS OF VAPORIZATION OF POTASH SOLUTION AS FUNCTIONS OF TEMPERATURE AND COMPOSITION
(*Verdampfwärme* = heat of vaporization.)

the following equation for the differential heat of vaporization is obtained:

$$q_d = r\,\frac{v_2 - v_1}{v'' - v'}$$

The specific volumes of the liquid v_1 and v' are so small as compared with the specific volumes of the gas that they can be completely neglected, hence

$$q_d = r\,\frac{v_2}{v''} \qquad [7]$$

It would appear, therefore, that for a given pressure the heat of vaporization is proportional to the specific volume since $\frac{r}{v''}$ is a function of the pressure only. Fig. 9 shows the heat of vaporization of a potash solution so obtained in its functional relation to the temperature and composition. This diagram, like some of the previous ones, may be expected to work very well for low pressures and not quite so well for higher pressures. The differential heat of vaporization may be also referred to as the sum of the heat of vaporization r of water, the heat necessary to superheat the steam up to the boiling temperature of the solution, and the heat of solution, which is liberated when 1 kg. of water at the boiling temperature of the solution is added to an infinitely large amount of solution of the composition ξ. This method of computation, however, cannot be applied when the boiling temperature of the solution lies above the critical

temperature of water, which is 374 deg. cent. or 705.2 deg. fahr. Technically it is just these high temperatures that are of importance. If one subtracts the differential heat of vaporization q_d from the heat content i_2 of the steam generated at a pressure P and temperature T_L abs. and then plots $i_2 - q_d$ on the ordinate axis of the i-ξ diagram (which the author does in the original article in his Fig. 11) a point P is obtained through which the tangent to the boiling curve passes at the proper composition ξ.

Having determined one such point, it becomes possible to construct the boiling curve. This point may be taken for any arbitrary point whatsoever and then the curve is determined for all the other pressures. If for any given composition ξ the specific heat of the solution is known, it becomes possible to compute the differences in the heat content of the boiling solution for different pressures if the boiling temperatures are known. Only a very few measurements of the specific heats of potash solution are available, and these are at 760 mm. of mercury and pressures below the boiling point. Starting with the specific heat of water where $\xi = 0$, it is found that the specific heat decreases with increasing content of potassium hydroxide. It is

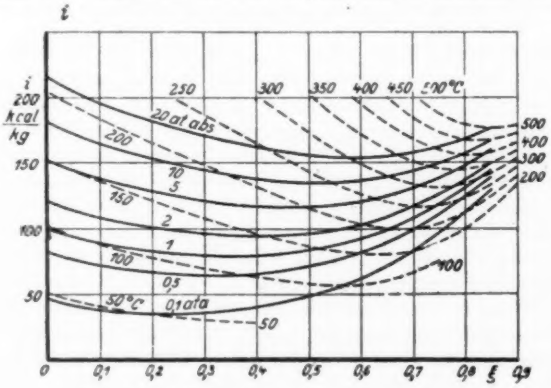


FIG. 10 i-ξ DIAGRAM FOR POTASH SOLUTION
(0,1, 0,2, etc. = 0.1, 0.2, etc.)

unquestionably dependent upon the pressure and temperature, and it would be extremely important to have a thorough investigation of this matter. Since at present nothing exact is known about it, the i-ξ diagram of Fig. 10 has been drawn under the assumption that the specific heat at 40 per cent by weight of potassium hydroxide in the solution ($\xi = 0.40$) is independent of pressure and temperature, and $c_L = 0.69$ kg.-cal. per kg. per deg. cent.

The shapes of the various boiling curves in this diagram determined by $i_2 - q_d$ seem to be about right, but their respective locations which are determined by the specific heats are not very certain. Should this diagram be applied for the computation of the thermal compressor according to Fig. 9, this uncertainty will materially affect the quantities of heat handled in the heat exchanger, but it has practically no influence on the quantities of heat exchanged in the evaporator and mixer, and it is these latter that are of prime interest in the practical operation of processes of this kind. Fig. 10 in addition to the boiling curves for the same pressure contains also in broken lines, curves of constant boiler temperature. When the specific heat of a solution is independent of pressure these curves give correctly the heat content of a non-boiling solution.

The author gives a numerical example of the application of the above. This it is necessary to omit here because of lack of space. (Dr. Ing. Friederich Merkel in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 72, no. 4, Jan. 28, 1928, pp. 109–115, 13 figs., *tA*)

Short Abstracts of the Month

AERONAUTICS

German Commercial Aeronautical Engines

DESCRIPTION of several types of engines. The B.M.W. (Bavarian Motor Works) engines are designed as supercharged engines, which means that they have the same output at great altitudes as on the ground, although they do not employ a special supercharger. They can also temporarily increase the engine output by 20 per cent, which is valuable in starting on rough ground or water or with an exceptionally heavy load. This is made possible by the altitude carburetor employed. Up to great heights it automatically provides all cylinders with the requisite most favorable gas mixture, and thus insures a minimum of fuel consumption at all points, especially when the engine runs throttled.

The new L 55 Junkers engine is said to have a continuous output of 560 b.hp. and a maximum output of 620 b.hp. It has a compression ratio of 5.5 to 1 and is of the V-shape with an angle of 60 deg.

The Siemens-Halske Co. builds air-cooled radial engines. The company is at present making systematic tests with a view to designing economical high-capacity engines of larger dimen-

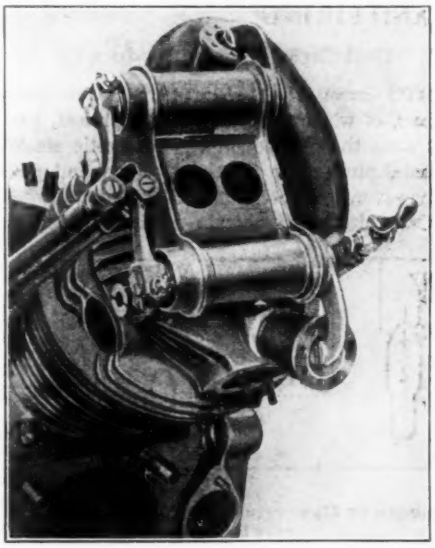


FIG. 1 SIEMENS VALVE-CONTROL GEAR FOR RADIAL AIRCRAFT ENGINE

sions. At present their engines are built in three sizes: five-cylinder, with a rated output of 62 to 72 b.hp.; seven-cylinder, 82–92 b.hp.; and nine-cylinder, 108 to 125 hp. Fig. 1 shows the patented valve-control gear of the Siemens radial aero engines which permits changing from clockwise to counter-clockwise rotation and exchanging admission and exhaust by reversing the rocking levers on the oscillating shafts. The latter are equipped with roller bearings. (Capt. Oefele, Munich, in *Engineering Progress*, vol. 9, no. 1, January, 1928, pp. 17–21, 7 figs., *d*)

The Turnbull Variable-Pitch Propeller

A SERIES of flight and whirling tests said to be successful have been carried out at Camp Borden, Ont., of the Royal Canadian Air Force, on a variable-pitch propeller designed by W. R. Turnbull, of Rothsay, New Brunswick, Canada. The

first full-sized propeller was shown at the Inventions Show, New York, in February, 1923.

The design is a composite one, i.e., a combination of wood, steel, and bronze, but an all-metal design is now under consideration.

The control mechanism involves a small electric motor mounted forward and at the center of the hub. The pitch can be regulated by alternating the gear ratio and power of the motor. In addition to this there is an electrical indicator on the pilot's instrument board showing just what changes of blade angle the pilot was making. The data of tests emphasizes particularly the climb test and the consumption test showing the importances of using variable-pitch propellers for long-distance flying. The reduced pitch for climb will make it possible to get a very heavily loaded machine off the ground, while the correct pitch with throttled engine will enable the machine to cruise at best cruising speed with a minimum consumption of fuel, and will enable to greatly increase the radius of flight. The details of construction are not given. (*Aviation*, vol. 24, no. 8, Feb. 20, 1928, pp. 446–448, illustr., *d*)

ENGINEERING MATERIALS (See Machine-Shop Practice: Machining Manganese Steel on a Commercial Basis: The Machining Properties of Brass Rod and Castings)

FUELS AND FIRING

Coal Carbonizing to Produce Oil

HITHERTO most of the low-temperature carbonization processes, of which so much has been heard, have had as their chief aims the production of a domestic smokeless fuel, with incidental products in the shape of tars and gases. Quite recently, however, a process has been demonstrated by the Rational Carbonization Syndicate Limited, which has as its

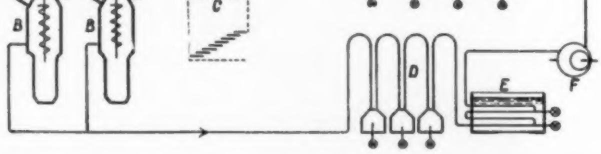


FIG. 2 DIAGRAM OF DEMONSTRATION PLANT, RATIONAL CARBONIZATION SYNDICATE

main object the production of oil, eliminating gas but of course leaving a residue of coke. The coke is friable, though it can be used as domestic fuel if required; it is mainly intended for industrial utilization in the pulverized form. Oil is, however, the chief product, and special attention has been given to avoid cracking it after its formation. By these means Dr. Dvorkovitz, the inventor and patentee of the system, claims that the production of gas can be eliminated. It is not clear, however, as to how the process utilizes the incondensable gases evolved; presumably they are employed as an auxiliary means of heating the retorts.

The demonstration took place at the company's premises, Slough, where two large-scale experimental retorts have been erected and where a small laboratory is available for small-scale experiments. On this occasion both retorts were in commission; they have a normal rating of 5 tons each per 16 hr., but were not being worked at this throughput.

In Fig. 2 *A,A* represent the fuel hoppers, fed by an elevator and furnished with gas locks. Within the retorts *B,B* are agitators; the main heating is due to the circulation of superheated inert gas through the retorts, but the latter are surrounded by brick flues around which the discharge gases from the superheater furnace are led. Temperatures of 200–400 deg. cent. are maintained in the retorts according to the class of coal being treated. From the retorts the gases (including the inert heating gas) pass to atmospheric condensers *D*, which serve to separate the heavy tars and oils, thence to water-cooled condensers *E*, where medium-grade oils are thrown down. A circulating compressor *F* is then interposed in the circuit, which afterward continues through scrubbers *G*, where the lighter fractions are absorbed in suitable oils for later redistillation. Incondensable inert gases then proceed into the superheater *C*, which has an inclined grate furnace, coke-fired. Large-scale commercial plants would have retorts of the continuous type, but the demonstration retorts work discontinuously. (*The Power Engineer*, vol. 23, no. 263, Feb., 1928, p. 60, *d*)

GAS ENGINEERING

Dehydration of Manufactured Gas

PROGRESSIVE gas men are giving increasing attention to this subject in the realization that a good many of their troubles are due to the presence of liquid water in the distribution system. Corrosion, drip pumping, frozen services, stoppages caused by rust, and meter troubles nearly disappear when means are taken to prevent condensation of water vapor from the gas in the distribution system. If this is done naphthalene stoppage troubles are also decreased, for there is no film of water to prevent naphthalene from being carried away by the first unsaturated gas that comes along.

It is by no means necessary to remove all the water vapor from the gas. Only as much need be taken out as is required to reduce the dewpoint of the gas below the lowest temperature it will encounter anywhere in the distribution system. If the dewpoint of the gas is 5 deg. below the ground temperature, there is little probability of ever having any water in the mains. This means, of course, that the permissible dewpoint is higher in the summer than the winter, also that nature is working with the gas man, for no matter how the gas is dehydrated, lower atmospheric temperatures make it easier.

Last summer, through the courtesy of and in cooperation with John A. Clark of the Public Service Electric and Gas Company, the author made a joint survey which indicated that the moisture content of the gas in the low- and intermediate-pressure systems operating at 12 to 14 in. of water, and 2 to 3 lb., respectively, was always nearly saturated under the conditions prevailing in the mains. Usually the dewpoint of the gas was only a degree or so below the temperature of the main. In the high-pressure system (35–50 lb.) the gas, first heated by the compression and then cooled in the mains, deposited water in the distribution system for several miles until it reached ground temperatures. Gas from the high-pressure main was supplied to numerous communities along it, and in most cases was expanded through governors directly into the local low-pressure system. At these lower pressures the dewpoint of the gas is about 35 deg. fahr., which means that the gas is practically dry as far as we are concerned.

There are several ways of dehydrating gas. It can be done by compression, which, however, is prohibitively expensive if used for the purpose of dehydration only. It may be done by cooling or by scrubbing the gas with a liquid which will absorb the water vapor from the gas. At Taunton, England, the gas is scrubbed in a Holme rotary washer with a strong solution of calcium chloride. Cooling coils maintain the circulating so-

lution at a constant temperature, and a portion of it is continuously directed from the circulating system and evaporated to remove water absorbed from the gas, thus maintaining the solution at a constant strength. This system is simply low in initial and operating costs, and has the ability to handle considerable overloads for several hours at a time.

The author cautions, however, about the dangers of adopting any hydration process which involves the use of calcium chloride. It was early tried in air conditioning where experience indicated that it was difficult to remove the last traces of calcium chloride spray from the air. If even traces of calcium chloride solution are carried out by the dry gases and deposited in the distribution system, increase in corrosion due to its presence will in time certainly more than offset the decrease due to the removal of water. Tests are being made on the use of certain non-corrosive salt solutions for gas dehydration. (G. A. Bragg in a paper presented before the New Jersey Gas Association, Trenton, N. J., Jan. 25, 1928. Abstracted through *Gas Age-Record*, vol. 61, no. 5, Feb. 4, 1928, pp. 149–150, *cp*)

INTERNAL-COMBUSTION ENGINEERING (See AERONAUTICS: German Commercial Aeronautical Engines)

LUBRICATION

A-M-L-O Lubricating Oil

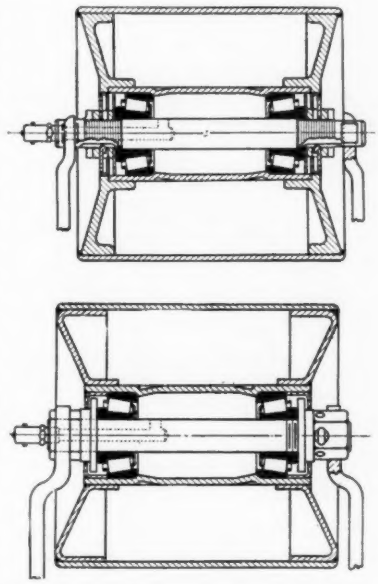
It is claimed that this oil of pure paraffin-base crude is 100 per cent free from wax. It has been developed by the Texas Pacific Coal and Oil Co. In developing such an oil the manufacturers believed that wax should not be merely reduced but eliminated entirely. Wax is said to have no lubricating value, and to act in addition as a diluent, lowering the viscosity of an oil and the operating temperature of the engine. While there are many paraffin-base oils on the market containing only a small amount of wax, it is said that even an oil having a pour test as low as 16 deg. fahr. contains approximately 1.5 per cent wax and is not safe for use in cold weather. It was considered that a perfect aircraft-engine lubricant would not become a reality until a method was devised to make paraffin-base lubricating oil 100 per cent wax-free. Additional new testing and refining equipment was necessary to do so, but it is claimed that it has been achieved now. (F. D. Bostoph, Sales Mgr., Texas Pacific Coal and Oil Co., in *Aviation*, vol. 24, no. 5, Jan. 30, 1928, pp. 261–262, illustrated, *d*)

MACHINE PARTS AND DESIGN

Roller Bearings on Conveyors

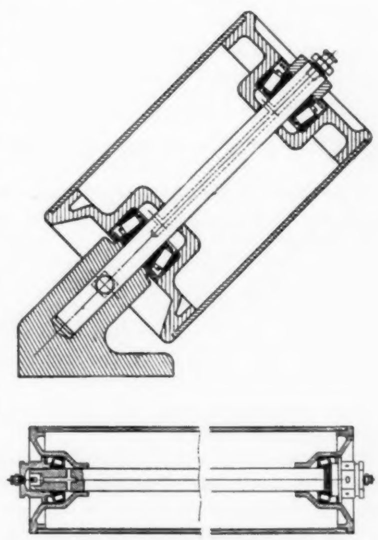
From a construction standpoint the application of roller bearings to belt-conveyor rolls is a very simple matter, the only important requirements being that ample provision must be made for the storage of enough lubricant to last over a considerable period, and that the possibility of the entrance of dirt or other foreign matter into the bearing housing must be eliminated as nearly as possible. The author deals practically exclusively with the practice of the Timken Roller Bearing Co., of Canton, Ohio. Figs. 3 and 4 show a typical belt-conveyor roller application. The bearings are mounted in a tube, or shell, which carries the body of the roller, and which is constructed so as to form a perfectly dust-tight and leakproof reservoir for the lubricant. The cups or outer races of the bearings are usually pressed into the tubes, and the cones given a slightly loose fit on the shaft, but not so loose as to permit any slippage.

By virtue of this construction, not only is shaft wear prevented, but there is no likelihood of the bearing seizing and causing the roller to wear spots on the belt. Lubrication in most modern installations is accomplished by the grease pressure method, the roller shaft either being counterbored, or left hollow, to permit access of the grease to the interior of the tube. There are various ways of constructing the outer closure, both simple and complex, but in either case it is easy to work out an inexpensive method that is highly effective, such as the use of labyrinth washers, for example.



Figs. 3 and 4 Typical Belt-Conveyor Roller Applications

In the case of larger rollers, concentrator rollers, return idlers, or others where for various reasons it is impractical to use the whole interior of the tube for holding lubricant, a different arrangement has been adopted which is shown in Figs. 5 and 6. In these two cases the tube mounting of the bearings is dispensed with, the roller being so constructed that the bearing cups can be pressed directly into the end frames, which are so designed as to form an inside seal for retaining the lubricant in the bearing chamber. The method of introducing the lubricant is the same—by boring and counterboring the shaft to afford a passage from the exterior to the reservoir. As a usual thing, the exterior closures are of the same construction as in the other rollers. An extra precaution is sometimes taken to seal the lubricant more positively in the lower bearing of concentrator rollers.



Figs. 5 and 6 Bearing Arrangement Adopted for Large Rollers

In order to obtain the fullest benefit from the use of antifriction bearings in belt conveyors, the installation should include the head and tail pulleys, take-up pulleys, etc. The bearing arrangement in the pulleys differs from that found in the conveyor rollers and return idlers, the variation being due principally to the difference in the load characteristics and requirements in the two types of installations, and the author presents some details of the design of this type of bearing.

In certain types of conveyors such as flight, pan, or apron, the bearings are usually mounted on wheels which are flanged

to run on tracks. Here the thrust loads which are always present in such a combination become an important factor in applying the bearings.

The author shows two typical examples of such a mounting. The cups are usually given a press fitting in the wheel hub (the dead-axle type) and the cones a metal-to-metal fitting on the axle.

Another type of installation which somewhat resembles that made on the conveyor wheels just described, but which is interesting because of the exceptionally severe service requirements, is the pallet wheels of slag conveyors used in steel mills. In this instance not only are the bearings subjected to heavy thrust and radial loads, but to relatively high temperature as well. The latter condition naturally tends to make proper lubrication of the bearings rather more of a problem than is usually the case. A typical example of such an installation is shown in Fig. 7. The bearing cups on both sides are pressed against shoulders machined in the wheel hub, and the cones are given a light fit on the shaft. The closures are of very simple but of very effective design, and prevent not only the leakage of the lubricant but the entrance of foreign matter under all conditions of heat. The lubricant is supplied through counterbored holes in the shaft, and the space between the bearings is utilized as a reservoir. The whole assembly is characterized by its strength and simplicity. [S. M. Weckstein (Mem. A.S.M.E.) Industrial Equipment Engr., Timken Roller Bearing Co., Canton, Ohio, in *Industrial Engineering*, vol. 85, no. 12, Dec., 1927, pp. 575–577 and 591, *dp*]

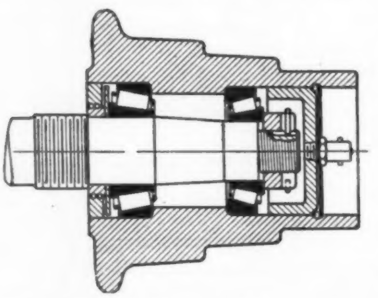


Fig. 7 Typical Bearing Mounting for Pallet Wheels of Slag Conveyors

MACHINE-SHOP PRACTICE

Machining Manganese Steel on a Commercial Basis

FOR some time tests have been conducted by the Firth-Sterling Steel Co., of McKeesport, Pa., on the cutting capacity of a new type of high-speed steel. This material was developed in the effort to produce a cutting medium that would give greater production than standard high-speed steels.

During the progress of the experiments, it was discovered that the standard test bars were not a sufficiently rigorous test of the capacity of this steel, and therefore it was decided to try manganese steel.

The test bars used were 3-in.-diameter rolled manganese steel with a content of about 12 per cent manganese and 1.20 per cent carbon.

The cutting test was unusual. All effort was directed to prevent tool failure. The test had for its object simply the practical purpose of demonstrating that manganese steel can be machined on a commercial basis. Commercial machining of manganese steel was held to imply that the tool must remove metal at a rate commensurable with the grinding process for at least two hours between grindings of the tool, so that a workman supplied with four such tools could do a day's work with no time lost for regrinding.

Nor were ideal operating conditions sought. The tests were carried on under circumstances that would obtain in almost any ordinary machine shop. The lathe used was a 24-in. back-geared cone-pulley belt-driven and gear-feed machine in fair condition. The lathe tools were forged from $^{7}/_{8} \times {}^{1}/_{4}$-in. bars of the new steel. These tools were similar in form to those used on heavy-duty work and in many cutting tests and had a front and side clearance of between 6 and 8 deg., a top back rake or clearance of 8 deg., and a top side rake or angle of 14 deg. The nose had a radius of $^{7}/_{16}$ in. (half the width of the tool). The cutting edge was on the center line of the work.

During the progress of the tests, cutting speeds ranging from $7^{1}/_{2}$ to 28 ft. per min. were tried. It was found that the range from $7^{1}/_{2}$ to 15 ft. per min. gave the best results. When suitable cutting speeds were established, various depths of cuts and feeds were tried. Within the speed range mentioned above, the tools stood up satisfactorily on feeds ranging from $^{1}/_{60}$ to $^{1}/_{30}$ in., taking cuts from $^{1}/_{16}$ to $^{5}/_{32}$ in.

In general, it was observed that for best results the work must be firmly chucked, the tool well supported with little overhang, and that the machine should be rugged. Chattering caused a considerable decrease in the life of the tool. All tests were run dry.

Summarizing the results, it is said that with tools made of the steel under test, manganese steel can be commercially machined using cutting speeds from $7^{1}/_{2}$ to 15 ft. per min. with depths of cuts up to $^{5}/_{32}$ in. and feeds of $^{1}/_{60}$ to $^{1}/_{30}$ in. Within the range of combinations of these variables the time of cut between grindings of the tools runs from one to nine hours. (A. S. Martin in *Iron Trade Review*, vol. 82, no. 9, March 1, 1928, pp. 564–565, *dA*)

The Machining Properties of Brass Rod and Castings

THE author states that it is not infrequently found that two consignments of brass rod bought to the same specification are entirely different in their machining qualities, and he has seen output reduced 25 to 35 per cent while the life of the cutting tools has been shortened to less than one-third of the normal through the employment of hard brass.

Brass of the 60/40 class which is a hot-working alloy is largely used for stamping, extruding, and rolling, so that usually the machining is carried out on metal that has been hot worked and in most cases not subjected to any annealing process. Furthermore an analysis of brass of that kind supplied by different makers will show that there is a great variety in composition, both in respect to zinc content and to the presence of other metals, such as iron, aluminum, lead, nickel, manganese, and tin. Their presence may have profound influence on the machining properties.

After a long series of experiments it has been found that the most easily machined brass is that containing approximately 60 per cent copper and 1.5 per cent lead, which has the same structure as an alloy containing exactly 60 copper and 40 lead. Therefore every care should be taken to obtain an alloy of this composition with none or little of other metals present.

It is commonly assumed that the machining properties of a metal depend upon its hardness, but this is not the case. If a Brinell, scleroscope, or any other hardness test be carried out on this alloy it will not afford any criterion as to its machining properties.

It has been frequently noticed that American 60/40 brass is easy to machine, and the reason is instructive. This class of brass is difficult to extrude, the result being that many British manufacturers make an alloy with a higher zinc content to facilitate the extruding operation. The American manufacturers in the main use much more powerful extruding presses than the British makers, and so they are able to produce extruded bar of the correct composition which can be more readily machined.

Another important point is that experience has shown that fibrous material is easier to machine than other classes. To

obtain the highest output on this material it is essential that the composition approximates to copper 60 per cent, zinc 38.5 to 39.0 per cent, and lead 1.0 to 1.5 per cent.

In the machining of castings, especially when high speeds are used, a cutting lubricant should be used as it increases production and decreases wear on tools. Many lubricants which are cheaper than oil can be used for general machining operations. These usually consist of a mixture of sal soda (carbonate of soda) and water, to which is added some ingredient such as hard oil or soft soap to thicken or give body to the lubricant. (*Brass World*, vol. 24, no. 1, Jan., 1928, p. 10, *p*)

MARINE ENGINEERING

The Pulverized-Coal-Burning S. S. "Mercer"

THE *Mercer* is a 9500-ton ship built by the Federal Shipbuilding Co. at Kearny, N. J., during the war. The vessel is fitted with a 2500-hp. General Electric turbine and three Scotch boilers. It was bunkered with ordinary North Atlantic range fuel containing a much larger percentage of slag than could be handled on grate bars.

Only two boilers were used for the entire voyage, and yet the *Mercer* beat the sailing schedule of a sister ship by 36 hours. It was equipped with a slow-speed pulverizing mill of the ball type which worked satisfactorily even when the roll of the ship was as much as 36 deg.

Certain mechanical difficulties developed during the initial trip, but were corrected as they arose. It is not stated just what they were.

In the discussion the following data were developed as to the personnel. This type of vessel generally has nine firemen and either three or six coal passers, depending upon bunker arrangements. The *Mercer* had three coal passers and three firemen, and the men appeared to have liked the job, which is not usual for this kind of service.

As regards pulverizers, it was stated that in this installation all three boilers were on one mill, which puts a tremendous load on the primary fan. According to the author of the paper, it is better for the sake of economy to have one individual pulverizer for each boiler. This would also increase the reliability of installation as it would not make the whole plant dependent on one common distributer. (C. J. Jefferson, Head of the Fuel Conservation Section of the U. S. Shipping Board, in an address before the Technical Committee of the American Steamship Owners' Association, New York, Jan. 9, 1928; abstracted through *Marine Engineering and Shipping Age*, vol. 33, no. 2, Feb., 1928, pp. 109–110 and 112, *gd*)

POWER-PLANT ENGINEERING

Recent High-Pressure-Steam Developments in Germany

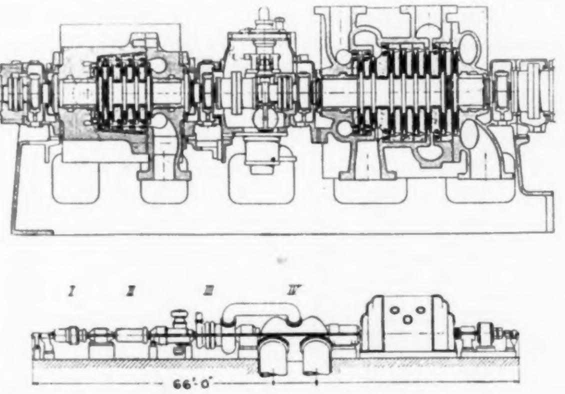
THE author treats the subject in a very general manner. The following is of particular interest.

For turbines above 5000 kw. capacity the high pressures effect a decided increase in efficiency. One 10,000-r.p.m. test turbine built for 1325 lb. pressure and 752 deg. fahr. operating with a Benson boiler at a back pressure of 181 to 206 lb., generates 1000 kw. and uses 22,046 lb. of steam per hr. Another 6000-r.p.m. turbine, shown in Fig. 8, intended to use 66,139 lb. of steam per hr. from a Benson boiler at 2734 lb. pressure and 788 deg. fahr. and 96 lb. back pressure, when operating with 96 lb. back pressure and carrying a load of 3000 kw., will be placed in service about the middle of next year.

For small outputs the reciprocating steam engine will attain increased importance for the high-pressure plant as well as an initial machine for low-pressure plants. Therefore, one company has built a vertical, double-acting, two-cylinder engine with a capacity of 1000 kw. at 3000 r.p.m. with 1764 lb. pressure, 914 deg. fahr. steam, and a back pressure of 191 lb.

In a larger plant the steam turbine is preferred. Fig. 9 shows the construction and details of an 18,000-kw., 3000-r.p.m., high-pressure turbine of the Erste Brunner type, designed to use steam at 1764 lb. pressure and 914 deg. fahr. The high-pressure rotor of the first stage will be enclosed by a two-section cast-steel housing. Steam enters at the left and leaves at 735 lb. at the right. The low-pressure section of the turbine housings III and IV, Fig. 9, is already in service at 200 lb. pressure. The high-pressure section of the turbine will be ready the middle part of this year. The boiler is being built and will be large enough to carry 5000 to 6000 kw.

The importance of high-pressure-steam operation is being



Figs. 8 and 9 Above—Turbine to Operate at 2734 Lb. Pressure (Under Construction). Below—Turbine Designed to Use Steam at 1764 Lb. Pressure

recognized by railroads and steamship lines, and the German government has ordered several high-pressure locomotives of various types, either with or without condensing equipment, some with steam engines and some with turbines. It was stated recently at a German shipbuilding engineers' meeting that if steam pressures on ships were increased 30 to 40 per cent with present grate coal firing they would operate more economically than Diesel-engine plants. Only after increasing the pressure, however, to 1500 lb. or more and introducing pulverized coal can the full benefit of high-pressure-steam operation be obtainable for marine work. (*Power Plant Engineering*, vol. 32, no. 3, Feb. 1, 1928, pp. 178–179, *g*)

Troubles with 1300 Lb. Steam Pressure

THE author deals with experiences at the Lakeside Station, and while he describes some troubles he states that the desirability of 1300 lb. steam pressure is unquestionable, and that its wide-spread adoption will occur in the very near future. On the whole, 11 boiler and 14 turbine stoppages have occurred in the 11 months of operation. Some of these were necessary for inspection. Some have been for rather expensive tube replacements, and one of 42 days was necessary for an air-meter change. This is illustrated in Fig. 10.

Scale Troubles. None have been experienced with 300-lb. boilers in their six years of operation, though evaporators were not employed and boilers were cleaned only at long intervals. The 1300-lb. boilers were fed only with evaporated make-up from the 300-lb. boilers. The first suggestions of tube trouble occurred after 880 hr. of operation. Inspection showed that a front-wall fin tube had bulged out near its upper extremity, presumably where highest heat transfer occurred due to nearness

to the burner tubes. Cutting of the tube into cross-sections showed that it was coated quite uniformly with $^1/_{32}$ in. of scale over the side exposed to the furnace, except at the bulge where scale filled nearly the entire extruded section. In the course of operation probably 50 similar bulges were observed, but no splitting of the tube with consequent explosive rupture occurred. Operation over two weeks with this kind of leakage has proved that high-pressure operation is entirely safe. Solids appear to have accumulated in the boiler water from condenser leakage into the feedwater. (First installment of an article by J. Anderson in *Engineering and Boiler House Review*, vol. 41, no. 6, Dec., 1927, 266–270, 4 figs., *d*)

The Kroepelin Patents on High-Pressure-Steam Production in Existing Boiler Plants

IT IS CLAIMED that these patents permit at a comparatively low cost the transformation of low-pressure plants to high-pressure, and this not only in large but especially in medium and small installations. The Kroepelin system, in the first place, is based on a more intensive utilization of the heat of the heating gases by the insertion of tube systems into the first pass of the gases, and, secondly, in the possibility of increasing at will the working pressure by means of additional boilers. The Kroepelin process adds to the original "mother" boiler an additional boiler for producing the high-pressure steam, and the handling of it depends on the plant conditions. Thus, it may be that the additional boiler may be called upon to supply high-pressure steam, say, at 30 atmos., while the mother boiler is used only as a hot-water producer. The hot-water or steam generation in the mother boiler will then be purely regulated by fitting the fire tubes with a firebrick lining ring so that that effect of the combustion gases will in the first place benefit the additional boiler. The regulation of the steam development in the mother boiler will then be determined by the length of the firebrick liner.

Instead of rebuilding completely the steam engines, high-pressure cylinders are merely built in. The author gives examples of various installations of which the following may be cited. With a two-firetube boiler of 100 sq. m. (1076 sq. ft.) heating surface and 12 atmos. pressure there are normally produced 2000 kg. (4410 lb.) of steam per hr. After the addition of a high-pressure boiler there are produced in the mother boiler 2000 kg. of steam and in the additional boiler 1500 kg., altogether 3500 kg. of steam at 12 atmos. The boiler output is thus raised by 75 per cent.

The author now considers a two-pressure plant, the additional boiler working at 30 atmos. After the transformation there will be produced in the mother boiler 2000 kg. of steam of 12 atmos. and in the additional boiler 1500 kg. of steam of 30 atmos.

With a counterpressure turbine the dropping of the pressure from 30 to 12 atmos. can be used for producing power. One therefore gains 70 to 100 hp. in power, and has besides 3500 kg. steam of 12 atmos. for his use as before.

To prove the economy and simplicity of the construction for the various types of boilers as well as the possibilities of application there are given in the following reports of tests a number of sketches and calculations regarding the financial aspect of the plant.

The first plant was installed in a briquet factory, and worked day and night without the least interruption for five months. It was a question here of a flue boiler which had been transformed for 15 atmos., and which in the preliminary trials had been used at this pressure. Later this additional system was joined to the general steam supply, and was operated at the available pressure working of 10 atmos.

The author refers next to the tests carried out under the supervision of the Cologne Steam Boiler Association, from which it would appear that considerable savings have been made. Figs. 11*a* and 11*b* show how the additional boiler is installed in connection with a two-flue boiler. The additional boiler consists of two cylindrical boiler bases of small diameter (500 to 700 mm., i.e. (19.6 to 27.5 in.). Each flue contains one such boiler. The thickness of the walls of these boiler bases are low in consequence of the small diameter. By means of an inserted division wall each boiler base is subdivided into a front and a back boiler. In the back drum bottom, hairpin-shaped boiler tubes 5–6$^1/_2$ m. in length are rolled. These tubes in the whole of their length nearly reach into the flues. One end of each tube is connected by means of special insertion pipes with the back of the drum, while the other end runs freely into the front drum part. Feeding is effected into the back drum part. The feedwater is thus pumped through the pipes. The front part of the drum, which takes in the water and water mixture, is in connection by means of vertical pipes with a steam collector, which is attached above the boiler, and which also is small in diameter. The steam collector is connected with the superheater. The feeding of the additional boiler is undertaken automatically by means of special feedwater regulators. The additional boiler can be fed either direct from the mother boiler or separately therefrom. The feedwater must be cleaned, as in every high-pressure boiler. The base drums as well as the steam collector are accessible through manholes. The base drums with the tube bundles can be drawn out, so that the mother and additional boilers can always be carefully examined without any difficulty.

In the latest construction the base drums described here are done away with, and are replaced by square pipes

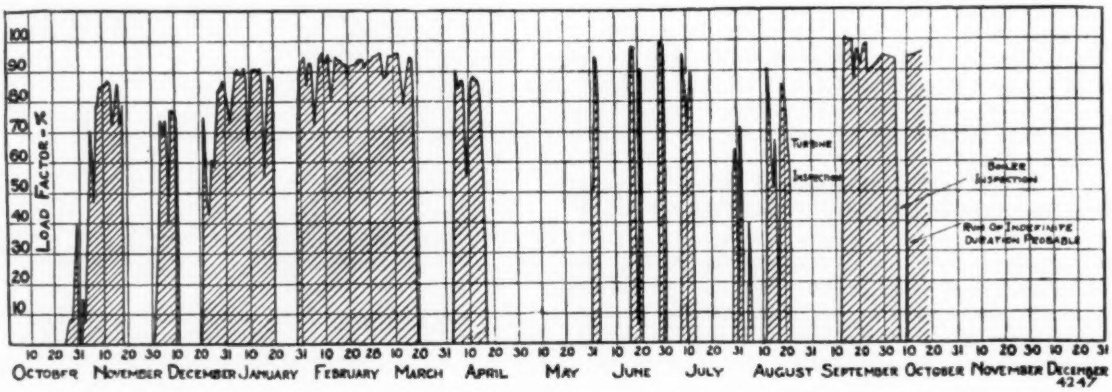


FIG. 10 SERVICE AND STOPPAGE PERIODS OF 1250-LB. TURBINE SINCE INITIAL STARTING

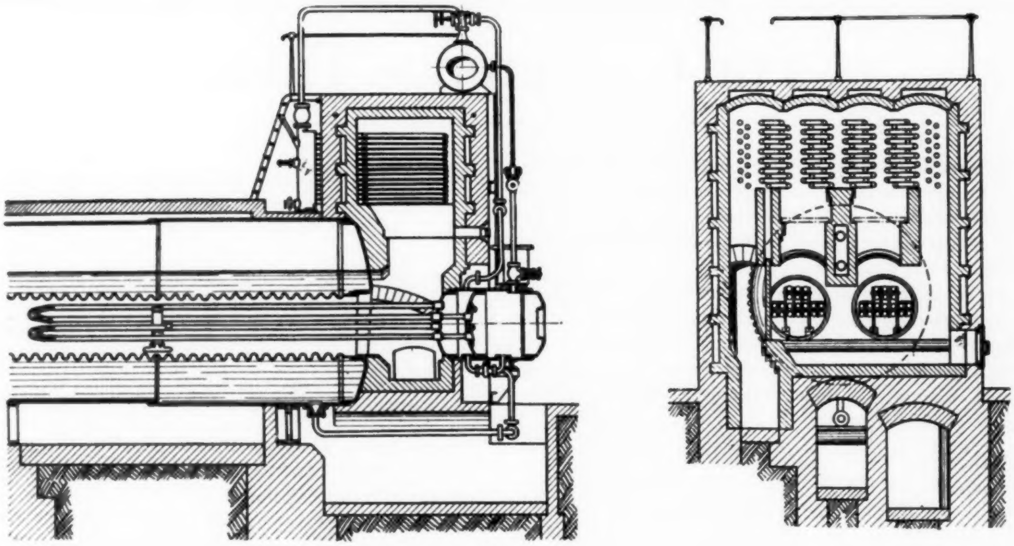


Fig. 11a

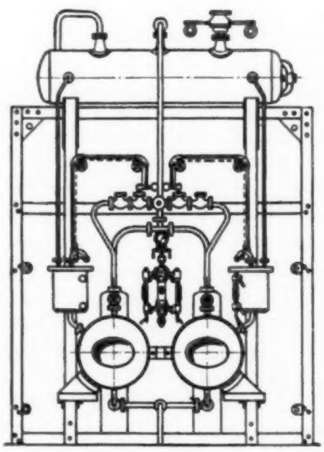


Fig. 11b

FIGS. 11a AND 11b HIGH-PRESSURE AUXILIARY BOILERS FITTED TO TWO-FLUE BOILER

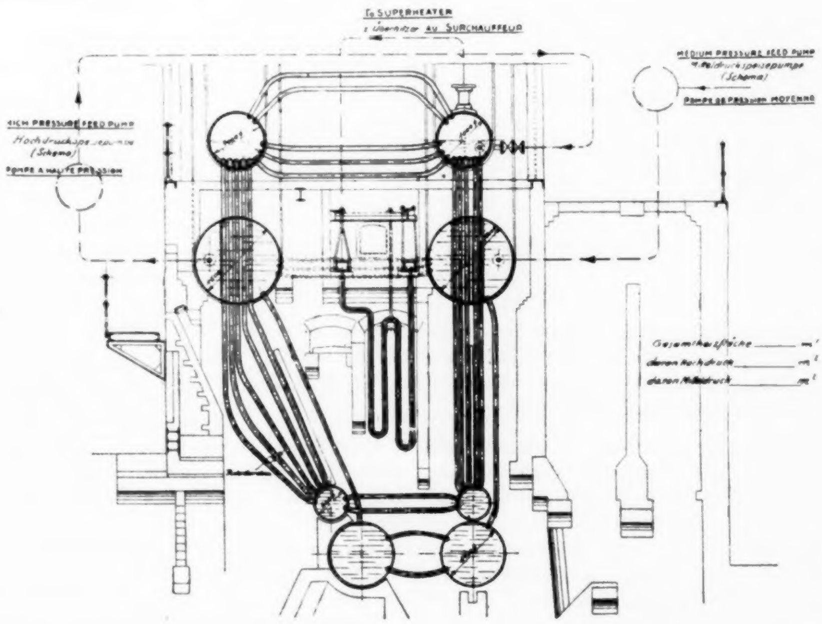


FIG. 12 HIGH-PRESSURE AUXILIARY BOILER FITTED WITH VERTICAL-TUBE BOILER

Fig. 12 shows an old transformed vertical-tube boiler. The water tubes of the old water-tube boiler, with the exception of a few situated on the two outer sides of the water chambers, are dismounted, and the openings are closed up by means of rolled-in support pipes. By this means the old boiler forms a preheater with regulated water circulation. The additional boiler is constructed of normal boiler tubes, which are carried through the tube supports, in connection with seamless drawn square pipes. The separate square pipes are connected with one another by means of rolled-in supports, and the opposite sides of the water tubes are closed in the ordinary way with covers. Under certain conditions the old covers which have been fixed to the old water chambers can be made use of again. (Geo. P. Shoos, Cologne-on-Rhine, in the first instalment of a serial article in *Engineering and Boiler House Review,* vol. 41, no. 8, Feb., 1928, pp. 359–363, illustrated, *dp*)

SPECIAL PROCESSES (See GAS ENGINEERING: Dehydration of Manufactured Gas)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled in this department.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK,
Aeronautic Division
A. L. KIMBALL, JR.,
Applied Mechanics Division
H. W. BROOKS,
Fuels Division
R. L. DAUGHERTY,
Hydraulic Division
WM. W. MACON,
Iron and Steel Division
JAMES A. HALL,
Machine-Shop Practice Division
CHARLES W. BEESE,
Management Division
G. E. HAGEMANN,
Materials Handling Division
J. L. WALSH,
National Defense Division
L. H. MORRISON,
Oil and Gas Power Division
W. R. ECKERT,
Petroleum Division
F. M. GIBSON and W. M. KEENAN,
Power Division
WINFIELD S. HUSON,
Printing Industries Division
MARION B. RICHARDSON,
Railroad Division
JAMES W. COX, JR.,
Textile Division
WM. BRAID WHITE,
Wood Industries Division

Applied Mechanics

Flange Design

AM-1 In designing companion flanges, how may one proceed to determine the following: thickness of flange, diameter of flange, number of bolts, and diameter of hub? What factor of safety is usually employed?

The paper by Everett O. Waters and J. Hall Taylor, on "The Strength of Pipe Flanges," presented at the 1927 Spring Meeting of the Society at White Sulphur Springs, W. Va., and published in the Mid-May, 1927, issue of Mechanical Engineering, contains much information of value on this subject. The discussion of the paper, published in the December, 1927, issue of Mechanical Engineering under the title "Methods of Determining the Strength of Pipe Flanges," covers proposed formulas for strength and deflection of rings, proposes a method of determining the strength of hubbed flanges, and offers a comparison of methods proposed in the paper with those in common use. It is recommended that both the original paper and the discussion be studied carefully.—Editor.

Tank Shell Thickness

AM-2 What may be considered a safe formula for determining the thickness of plate for large riveted or welded tanks, say, 25 in. in diameter and 60 in. long, under external pressure?

A formula recommended by the American Bureau of Shipping for "Circular Furnaces" specifies that the maximum working pressure, when plain or fitted with reinforcing rings, shall be as follows:

$$W = \frac{16{,}000}{D}(T - 0.003L - 0.03); \quad T = \frac{WD}{10{,}000} + 0.003L + 0.03$$

where

W = working pressure in pounds per square inch
T = thickness of plate in inches
L = length of furnace, or distance between reinforcing rings; total width of C. C. wrapper sheet, or distance between reinforcing bars or distance between stays
D = smallest outside diameter of furnace, in inches.

The thickness of any furnace should not exceed $^{13}/_{16}$ in.

The physical characteristics of the furnace plate are in accordance with Sec. 40, Par. 3.

To find the required thickness for a tank 25 in. outside diameter by 60 in. long, to operate under, say, 175 lb. external working pressure, substitute in the above formula and solve:

$$T = \frac{175 \times 25}{16{,}000} + 0.003 \times 60 + 0.03 = 0.4834.$$

Therefore $^{31}/_{64}$ in. is the thickness required. (L. H. Burkhart, Chief Engineer, Struthers-Wells Co., Warren, Pa.)

Fuels

Operating Efficiencies with Middle-Western Coals

F-1 On middle-western coals, such as those of Indiana, Illinois, Missouri, and Kansas, what are the best monthly operating efficiencies which have been obtained (*a*) on chain-grate stokers and (*b*) on underfeed stokers? Describe conditions under which these results have been obtained.

Eighty-five per cent with water-screen furnaces, 1600-hp. boilers with superheaters, about fifty per cent economizer surface, and 100 per cent preheater surface, forced-draft, chain-grate stoker. Eighty-eight per cent with refractory air-ventilated walls, 1000-hp. boilers and superheaters, fifty per cent economizer surface, bled-steam air preheater, multiple-retort underfeed stokers. (J. G. Worker, Asst. to President, American Engineering Company, Philadelphia, Pa.)

Economical Fineness of Pulverization

F-2 In a pulverized-fuel boiler furnace the finer the pulverization, other things being equal, the more complete is the combustion in a given furnace. Conversely, however, finer pulverization requires more power per ton of coal pulverized. What have operators and manufacturers found to be the most economical fineness of pulverization (*a*) in unit-fired installations and (*b*) in central-plant installations? Describe also conditions under which these results have been obtained as to maximum heat released per cubic foot of furnace volume, fusion temperature of ash used, etc.

Fineness and economy depend upon too many conditions to be stated briefly, such as quality of coal, load factor, etc. A very rough figure may be taken as seventy-five per cent through 200-mesh. Fusion temperature of ash has little effect on economical fineness. The present maximum heat release for most conventional systems seems to be 30,000 B.t.u. per cu. ft., but

ratings above 50,000 B.t.u. per cu. ft. have been attained with fuel having a fusion temperature as low as 2000 deg. fahr. in one installation. (W. W. Caldwell, Asst. to the Genl. Supt. of Power Plants, United Electric Light & Power Co., New York, N. Y.)

Air Jets as Aid to Smoke Abatement

F-3 Is the introduction of air jets over the fuel bed of an underfeed stoker beneficial in the reduction of smoke, and will the use of such jets prove detrimental to efficiency in any way?

(*a*) Best results are obtained by introducing jets of highly preheated air in the furnace, aimed at the coking zone of the fuel bed. The jets must have a considerable penetrating power. The turbulent action is produced at or near the fuel bed, causing a thorough mixture of the over-fire air with the volatiles, and a complete oxidization of them up to the amount of air injected into the furnace, which should never exceed 10 per cent with underfeed stokers. The turbulent action will cause a thorough mixture and complete oxidization of the remainder of the volatiles with the free air passing up through the fuel bed. The air should preferably be taken from the stoker wind box so that the amount injected into the furnace is always in proportion to the rate of combustion. This writer's company has used the system with its air-cooled walls, and the combination of a refractory preheater and over-fire air jets is the subject of a patent application.

The design of the orifice nozzle is of prime importance, and we have succeeded in developing a refractory nozzle that gives great penetration, nearly 40 in. having been observed with a 4-in. stoker wind-box pressure. Increased efficiencies, ranging from 1 per cent to 4 per cent, due to this system, have been observed, the higher increases, however, being upon overfeed stokers.

With sufficient penetration and proper turbulent action of the gases, the fly-ash deposits in the tubes and breechings have been materially reduced. Cold air is not as effective as preheated air. The action required is mechanical, and the less air used on underfeed stokers, the better. Highly preheated air gives from 50 per cent to 100 per cent increased volume over cold air, and as the action is mechanical, the volumetric effect of the air is required rather than the weight. Over-fire air allowed to seep in through the front walls of the furnace tends to increase rather than break up stratification. (S. M. Finn, General Manager, Drake Non-Clinkering Furnace Block Co., Inc., New York, N. Y.)

(*b*) The writer in his practice has found the use of air jets very beneficial in the reduction of smoke, especially when using free-burning western coal. There have been cases where the introduction of air over the fire has increased the CO_2 and efficiency. (Osborn Monnett, Consulting Engineer, St. Louis, Mo.)

(*c*) The air jets are beneficial in the reduction of smoke. The use of such jets will, when they are properly proportioned and located, increase the efficiency. (R. A. Foresman, Chief Engineer, Stoker Department, Westinghouse Electric and Manufacturing Co., South Philadelphia Works.)

Stoker Maintenance

F-4 How much in cents per ton should average stoker maintenance run for (*a*) underfeeds, (*b*) chain grates? Please state what part of figures given are for material and parts, and portion allotted to labor of installation. Also, state length of period over which the figures given have been averaged and how recently they were compiled.

The following figures were obtained over the past five years, and were compiled continuously. (R. A. Foresman, Chief Engineer,

Coal	Material cost, cents	Labor cost, cents
Middle-western	1½	1
Low-ash, Appalachian region (bituminous)	5	2½
High-ash, Appalachian region (bituminous)	2½	1½
Eastern semi-bituminous	4	2

Stoker Department, Westinghouse Electric and Manufacturing Co., South Philadelphia Works.)

Textile

Long-Draft Cotton Spinning

T-1 What is the Textile Division of the Society doing in the way of investigating and recording the latest developments in long-draft cotton spinning of yarn in this country? Also, has the Division contributed anything to the records of the Society on plant efficiency, with particular reference to reorganization of existing plants?

Regarding the first portion of the question, the Textile Division has in process of preparation a paper on this subject in which the fundamental principles of the different methods of long-draft cotton spinning will be discussed. This paper will be presented at a meeting either in the spring of 1928 or the fall of 1929. For the second part of the question the inquirer is referred to a paper by Henry Morgan Burke on "A Steam-Loss-Prevention Plan Operating in a Textile Plant," contributed by the Textile Division and presented before the Annual Meeting of the Society in 1923. This paper appears in the Transactions for 1923, page 405. Details of a simple and elastic method installed in the power department of a large textile-finishing concern, making it possible to diagnose daily plant operation, are given. (James W. Cox, Jr., Consulting Textile Engineer, New York, N. Y.; *Chairman*, Textile Division, A.S.M.E., for 1928.)

Questions to Which Answers Are Solicited

F-5 A certain power plant is equipped with four 350-hp. boilers in two settings of two boilers each. Hand-fired, using anthracite (buckwheat), the coal consumption was 1150 tons per month over a two-year period, with a rating of 70 per cent. It is said that the conversion of two boilers to pulverized-coal burners resulted in a coal consumption of 275 tons of slack for 420 steaming hours at 140 per cent of rating. The two boilers burning anthracite consumed 611 tons in 600 steaming hours during the same month. Readers are asked to criticize these figures, as they have aroused doubt as to their authenticity.

Repair Costs

MG-2 What is a reasonable figure for yearly repair costs of lathes, milling machines, planers, etc., as a percentage of the original cost of the machines?

Disposal of Sand-Blast Sand

MH-3 What are the opinions of readers of Mechanical Engineering regarding the possibility of disposing of sand from sand-blast rooms by blowing it through pipes to a river approximately 100 ft. away. Approximately three cubic yards of sand per hour must be handled. What size of fan or fans is recommended and where should they be located—at the source, point of delivery, or both?

Engineering and Industrial Standardization

Standardization of Refrigerators

A GENERAL conference of manufacturers, dealers, and consumers to consider the standardization of refrigerators will be held in New York early in April under the auspices of the American Engineering Standards Committee. A preliminary meeting was recently held to consider requests for standardization received by the Committee from the American Home Economics Association and the American Institute of Architects. It was the view of both of these bodies that specifications and standards which would tend to bring about improvements in the food-keeping performance and ice economy of household refrigerators should be developed on a national scale under the auspices of the American Engineering Standards Committee, with the possible establishment of carefully defined grades so that the buyer of a refrigerator could be assured of certain performance at the price range he was able to pay.

All representatives at the preliminary conference were agreed that work along standardization lines was necessary, and that it should be accompanied by education of consumers to the proper selection and use of refrigerators. It was pointed out that the economic questions involved are too important to be neglected; for example, an extra inch of efficient insulation in a refrigerator will pay dividends at the rate of 18 per cent on a box used only six months out of a year.

It was also pointed out that the problem is closely related to public health, since there is a rapid increase in food spoilage at the temperatures of 65 to 70 deg. fahr. which sometimes obtain in ice boxes during hot weather. Because of this, the United States Bureau of Public Health, the Navy Department, and the Bureau of Standards are closely concerned with the project.

Representatives at the preliminary conference were: William Fitzgerald, of the National Retail Dry Goods Association; David Fiske and V. H. Greene, of the American Society of Refrigerating Engineers; J. N. Nickerson, of the American Institute of Refrigeration; Dr. Mary E. Pennington, of the National Association of Ice Industries; Dr. Louise Stanley, of the American Home Economics Association; Commander H. N. Wallin, of the United States Navy Department; and Reuben S. Ottenheimer, of the Commercial Refrigerator Manufacturers Association.

As stated in these columns many times before, the procedure of the American Engineering Standards Committee, under which the standardization will be carried on if favorably acted upon at the conference next month, provides for full representation of all established interests with no one interest in the majority, be it producers, consumers, or general public (except with the formal consent of the other groups concerned). Committees are made up of formally accredited delegates whom each industry itself selects to represent its interests. Where a trade association exists, it represents the industry in so far as it covers the field; outside its field all or part of the representation may be obtained by direct nomination of individual firms.

Among the organizations which will probably be invited to name delegates if the conference decides to initiate the work will be: Federal Specifications Board, U. S. Bureau of Standards, U. S. Bureau of Public Health, U. S. Bureau of Home Economics, American Home Economics Association, American Institute of Refrigeration, American Society of Refrigerating Engineers, American Institute of Architects, American Hospital Association, American Hotel Association, National Association of Ice Industries, National Refrigerator Manufacturers' Association, National Retail Dry Goods Association, National Association of Retail Grocers, Electric Refrigerator Manufacturers' Group, National Store Fixtures Association, National Retail Hardware Association, National Association of Retail Furniture Dealers, National Association of Building Owners and Managers, National Association of Apartment House Owners, and National Commercial Fixtures Manufacturers' Association.

As part of its effort to consider the point of view of all groups before undertaking the work, the American Engineering Standards Committee invites comment and suggestions on this project from those interested in domestic refrigeration. Address replies to C. B. LePage. Assistant Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

Standards for Radio Apparatus

NEW impetus to the nation-wide effort to stabilize the radio industry while speeding its progress along sound economic lines through the establishment of national standards of construction and quality of radio apparatus, was recently announced by the American Engineering Standards Committee, following the election of Dr. Alfred N. Goldsmith, president of the Institute of Radio Engineers, to the chairmanship of the committee on radio standardization, which has been doing pioneer work in the radio industry.

Because of the importance of the work to the Government, the radio committee includes in its membership representatives of the departments of War, Navy, and Commerce, as well as representatives of the radio industry and interested national associations and groups. Other radio committee officers recently elected are Dr. Clayton H. Sharp, of the Electrical Testing Laboratories, vice-chairman, and Dr. C. B. Jolliffe, of the U. S. Bureau of Standards, secretary.

The standardization activities of all national organizations concerned with radio will be brought into concert for the benefit of the industry and the public by the work of this Sectional

NEW A.E.S.C. STANDARDS

The following standards were approved by the A.E.S.C. during the month of February 15–March 15, 1928:

Code for Electricity Meters. (American Standard.)

Sponsored by the Association of Edison Illuminating Companies, Bureau of Standards, and the National Electric Light Association. Published by the N.E.L.A.

Specifications for Dry Cells. (American Standard.)

Sponsored by the Bureau of Standards. Published by the Government Printing Office.

Plow Bolts. (Tentative American Standard.)

Sponsored by the Society of Automotive Engineers and the A.S.M.E. Published by the A.S.M.E.

Committee. Standards for vacuum tubes, electro-acoustic devices, transmitting and receiving sets and installations, component parts and wiring, and power supply and outside plant are being developed.

The rapid growth of radio during the course of a few years, making it one of the nation's largest industries, with 7,000,000 receiving sets in use, has led to the manufacture and sale of numerous devices the nature of which the purchaser hardly understands. The announcement points out the desirability of producing standard definitions of terms descriptive of radio receiving apparatus, which would enable and encourage the use of such terms in the sale of equipment, thereby replacing the vague designations of the characteristics of receiving sets by precise terms which would be informative and helpful to the purchasing public.

One of the standards being recommended by the Sectional Committee for adoption by the sponsor societies and submittal to American Engineering Standards Committee proposes a single national standard of dimensions for the 4-pin-vacuum-tube base. The establishment of such a standard will insure tubes produced by any manufacturer fitting into sockets produced by other manufacturers.

A.S.M.E. Boiler Code Committee Work

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in Mechanical Engineering.

Below are given records of the interpretations of the Committee in Cases Nos. 557 and 579 as formulated at the meeting on January 13, 1928, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

Case No. 577

Inquiry: Does Par. P-195 of the Code mean that when a dished head has a flanged access hole of any size, the plate must be increased $^1/_8$ in. in thickness, or is the $^1/_8$-in. increase required only when the hole is large enough to admit a man?

Reply: The requirement in Par. P-195 for the increase of $^1/_8$ in. in thickness refers specifically to access openings of sufficient size to admit of entrance to the interior, but it is the opinion of the Committee that in any case where an access opening exceeds 6 in. in any dimension, the head should be reinforced by the increase of $^1/_8$ in. in thickness.

Case No. 579

Inquiry: Is it permissible, under the requirements of Par. M-7 of the Code, to attach the heads to the shells of miniature fire-tube boilers by fusion welding if the stress on the heads is supported by through staybolting or suitable stay tubes?

Reply: Par. M-7 of the Code permits of the use of fusion-welded joints only where the stress is carried by other construction which conforms to the requirements of the Code. It has been proposed to revise the requirement of Par. M-7 pertaining to the construction of head joints of fire-tube boilers by the addition of the following:

> The joints between the heads of miniature fire-tube boilers and the cylindrical shells may be sealed by fusion welding provided the shell is chamfered to receive the head, and the staybolts or stay tubes are inserted between the heads with their centers on a circle which comes not over one-third the maximum allowable pitch from the inside of the shell, and said staybolts or stay tubes are spaced apart on said circle at distances not over one-half the maximum allowable pitch. The maximum allowable pitch referred to is that considering the head as a stayed surface. A tube two gages thicker than required for the maximum allowable working pressure, which is rolled into the head and beaded, may be considered the equivalent of a stay.

Harvard Business School Summer Session for Executives

The Harvard Business School has announced a Special Session for Business Executives to be given at the School during the coming summer.

The following subjects will be available: Accounting Policies; Business Policy and the Law; Finance; Marketing, Sales Management and Advertising; Marketing, Retail-Store Management and Advertising; Public-Utility Management and Economics; and Railway Transportation.

Each course will require the full time of the student, and classes will meet for four hours daily. The case method involving informal discussion of actual business problems will be followed.

The course in Accounting Policies will be in charge of Prof. W. M. Cole, Prof. T. H. Sanders, Asst. Prof. A. W. Hanson, and H. N. Sweet of Lybrand, Ross Brothers & Montgomery in Boston. "Business Policy and the Law," which will aim to bridge the gap between law and business, will be offered by Prof. Nathan Isaacs, and Earl S. Wolaver, assistant professor of business law in the University of Michigan. "Finance" will be given by Prof. Arthur Stone Dewing and Asst. Prof. C. E. Fraser. The two courses in marketing will be in charge of Prof. M. T. Copeland, Prof. H. R. Tosdal, Prof. H. T. Lewis, formerly dean of the School of Commerce at the University of Washington, Asst. Prof. M. P. McNair, and Asst. Prof. N. H. Borden.

"Public-Utility Management and Economics" will be in charge of Prof. Philip Cabot, and Deane W. Malott, instructor in public-utility management. This course was given last summer, with thirty-five public-utility executives from all parts of the country in attendance, and as a result of its success the special session for the coming summer was undertaken.

"Railway Transportation" will be given by Prof. W. J. Cunningham and Prof. W. M. Daniels of Yale University.

The living halls of the new Harvard Business School, built under the George F. Baker Foundation, will be open for the session, according to Prof. O. M. W. Sprague, acting dean of the School, and will offer an opportunity for intimate contact on the part of the business men who attend the session.

The special session will be primarily for business men but a limited number of teachers of business will be admitted.

Registration is scheduled to commence on Saturday, July 7, and final examinations are to be held on Saturday, August 18.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

The American Society of Mechanical Engineers

29 West 39th Street, New York

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Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

BY-LAW: The Society shall not be responsible for statements or opinions advanced in papers or.... printed in its publications (B2, Par. 3).

Transactions in Its New Form

RESPLENDENT in its green cover the first section of Transactions appeared early in March. This section was devoted to internal-combustion engineering, and the Oil and Gas Power Division had the honor of making the initial contribution to this new series of publications. A little later the Applied Mechanics Section appeared, and then the Hydraulics Section. Others will follow in quick succession. In general, the make-up and form of the new Transactions seem to have been favorably received. So far there is no reason to believe that the new policy will not satisfy the needs of the membership to a much greater extent than the old procedure of issuing an annual bound book several months later in the year.

The material appearing in the sections of Transactions will not be duplicated in MECHANICAL ENGINEERING. The two publications are made approximately the same size so that their pages may be filed together when so desired.

Mechanical Engineering Expositions

DURING the past five years mechanical engineering and the industries which depend upon it have been stimulated by a number of splendid expositions in the broad field which it covers. In general, these expositions have revealed important information to those who attended them and brought increased business to those who exhibited.

The visitors at these shows value them for their great educational value. The exhibitors appreciate this educational function but they regard the shows generally as advertising and selling functions. While a manufacturer may govern his advertising in the technical press and his direct mail circularization according to the demands of his own business and the developments of his products, in the planning of his exhibits he is generally governed by what the great body of his competitors want to do. In this way the increasing number of shows appears to be placing more of a burden—and an unwelcome one—on the manufacturing industries than other types of advertising or publicity.

In general, shows are good things, and the more of them there are and the better their geographical distribution, the better pleased the engineering profession will be. However, the burden upon the exhibitors increases rapidly with an increase in the number of shows, and the law of diminishing returns takes charge. It would seem, therefore, that shows are good only to the extent that they provide new ideas and devices for the visitors and a reasonable amount of business for the exhibitor without placing an undue burden on him. To attain this desirable end, close cooperation among all concerned in the planning and conduct of shows of all types is necessary.

The Daniel Guggenheim Fund for the Promotion of Aeronautics

THE first report of this Fund, covering a period of two years, has been recently published. These two years have been momentous in the history of aeronautics. In the first place, there have been many spectacular achievements, such as several flights across the Atlantic, a flight to the North Pole, another one half-way across the Pacific, etc.

Air-mail business has passed into private hands and a foundation for commercial aeronautics in the United States without government subsidies has been laid. In other respects, however, it would appear as if comparatively little progress has been achieved. Passenger transportation is practically non-existent and the carrying of express matter by air is still in the future.

The promotion of aeronautics involves two main problems: the development of an aerodynamically safe aircraft with the proper facilities for navigation, including airways and landing fields and an adequate foreknowledge of weather conditions; and the recognition of this development by the public through education. Long-distance flights are generally both experimental and educational, and laboratory achievements are often of sufficient interest to contribute to public knowledge.

The Daniel Guggenheim Fund is one of those private undertakings in the same class as the various Rockefeller funds for combating diseases all over the world, and can perform services and promote movements which apparently could not be done by any other agency. The purpose of the Fund is to assist in and not primarily initiate the technical development of aeronautics, and to create a healthy public interest in the welfare of the new art. As the success of commercial aeronautics depends on actual demonstration that airplanes are inherently no more dangerous than steamships or railroads, the Fund set as its first objective the development of safety in aviation. With this in view it has organized a Safe Aircraft Competition, the aim of which is to coordinate the various safety features into one plane. The competition is international, and offers several prizes of generous proportions.

The Fund has also been interested in stimulating the study of aeronautical science in the universities of this country, in addition to providing means for research work to contribute to the perfection of the airplane of the future.

It was never intended that the Fund should be a permanent organization. Its purpose will be realized when aviation has been advanced to such a point that private enterprise will be able to carry on by itself. Accordingly the Fund has made contributions of its principal to various organizations which were in a position to be useful in the promotion of aeronautics. This

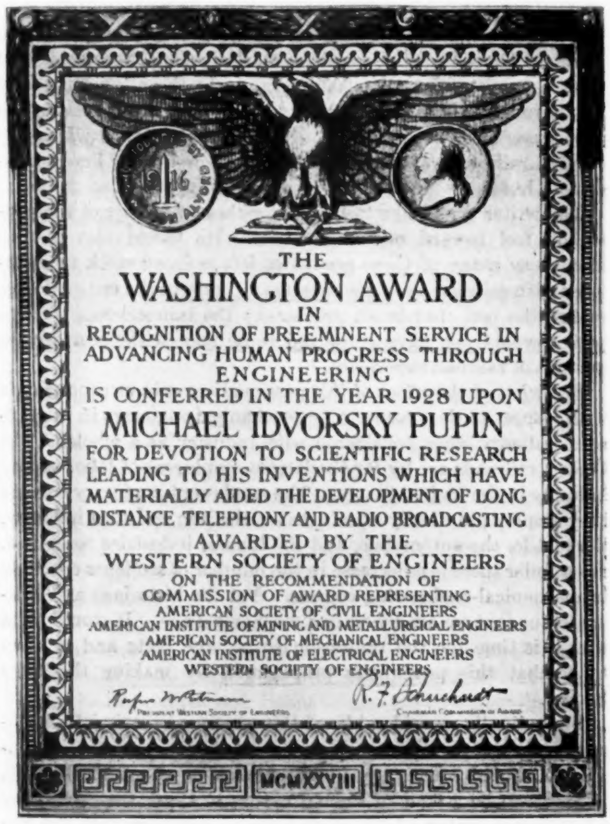
expenditure seemed both appropriate and wise: appropriate because of the express wish of the donor, who had in mind the training of the youth of the country for opportunities in a new and uncrowded profession, and wise because any money carefully spent for education should give a sure, though perhaps not a spectacular or immediate, return.

While only two years old the Fund has been remarkably successful in establishing for itself a recognized position in aeronautics, and engineers will be looking to it and possibly other similar movements as important constructive agencies in furthering the development of a means of transportation which may ultimately prove to be as decisive in shaping national destinies as was in its own time railroad transportation.

Previous to the establishment of the Fund, Mr. Guggenheim had created a school of Aeronautics at New York University. Following this example the Fund has made four grants totaling $808,000 to as many American universities in order to equip them for research and instruction in aeronautical science.

Dr. Pupin Receives Washington Award

Dr. Michael Pupin, of Columbia University, noted scientist and inventor, was presented with the Washington Award on February 2 "for preeminent service in the promotion of human happiness, comfort, and well being." The presentation was made in the Grand Ball Room of the Palmer House, Chicago, at an evening function sponsored by the four founder national societies and the Western Society of Engineers. Following the banquet, with 450 in attendance, Maj. Rufus W. Putnam, president of the Western Society of Engineers, reviewed the founding of the award by John Watson Alvord, and named the previous recipients. R. F. Schuchardt, chairman of the award commission and also chairman of the meeting, eulogized the honored guest and introduced the various speakers of the evening.



Speaking for President Max Mason, of the University of Chicago, Prof. Arthur Compton, Nobel prize winner last year, outlined what Doctor Pupin had accomplished in the realms of invention and development. The most notable of his accomplishments were his method of loading telephone cables which made long-distance telephony possible, the tuned circuit and the resonant system now used as a basis of all radio broadcasting, rectification of alternating currents, and development of X-ray photography.

Representatives of the four national societies followed with expressions of felicitation and hearty concurrence in the award. Dr. A. N. Talbot, a previous recipient, spoke for the American Society of Civil Engineers; Dr. William Kelly, of Iron Mountain, for the American Institute of Mining and Metallurgical Engineers; John Lyle Harrington for The American Society of Mechanical Engineers, and Bancroft Gherardi, president of the American Institute of Electrical Engineers, for his society.

In his response Doctor Pupin dwelt particularly upon the long-distance telephone. All large industrial centers in this country were being connected into one telephonic community and Europe would follow suit. In this rapid interchange of ideas he saw a factor for world peace, because nothing was so conducive to friendship as thought expressed by the living voice.

Clearing the International Barrier

At 10:30 O'CLOCK on the morning of Thursday, February 16, 1928, Bancroft Gherardi, president of the American Institute of Electrical Engineers, stepped to the speakers' desk in the Engineering Auditorium in New York City with the words, "Good morning, Mr. Page."

Promptly, clearly, and well enunciated came the reply from a cluster of loud speakers suspended above the stage: "Good afternoon, Mr. Gherardi." Archibald Page, president of the British Institution of Electrical Engineers, standing before an afternoon meeting of the Institution in London, was the speaker.

Thus was opened the first joint session of two national engineering societies on opposite sides of the Atlantic, each remaining in its respective meeting hall, yet interchanging greetings and discussing problems of the hour with no more difficulty than if they were sitting together.

Seconding a motion for the adoption of a resolution commemorating the occasion, proposed by Gen. John J. Carty, Sir Oliver Lodge said: "The unison and permanent friendliness of all branches of the English-speaking race, now let us hope more firmly established than ever, is an asset of incalculable value to the whole of humanity. Let no words of hostility be ever spoken."

We may gain some knowledge of the possible advantages to be obtained from future meetings of this nature when we reflect for a moment on the impressions almost inevitably received by those who regard each other from afar, relying wholly on the written word and hearsay for information as to accomplishments. A certain amount of suspicion creeps in, and each pictures the other as having overgrown opinions of rather undersized achievements. Personal contact, or even the spoken word, often alters completely quickly formed, erroneous impressions. Engineers, through the medium of the radiophone, have cleared the international barrier, and now, with the ability to hold frequent joint meetings with their brothers in other lands, it would seem that ere long we shall have reached that state of mind in which there shall indeed be no words of hostility spoken. Then the purposes for which all real engineering societies were founded will attain a new measure of fulfilment.

The Mechanical Engineer in Industry

WHEN the Executive Committee of the Railroad Division delegated to its Survey Committee the task of collecting facts and data pertaining to the opportunities afforded the mechanical engineer in the railroad and railroad-supply industries, it had no idea that the project would be so extensive as it turned out to be, nor did it expect that the project would be so opportune. The subject "Do the Railroads Want College Men?" had for a number of years been one of considerable interest to railroad men, and many editorial comments, articles and "letters to the editor" had frequently been appearing in the railway trade press. As was stated in the progress report[1] presented at the Annual Meeting, December, 1926, by the Sub-Committee on Professional Service, most of the opinions expressed in the letters to the editor were of such a pessimistic nature that it was practically impossible to obtain other than a gloomy picture of the future for the mechanical engineer in the railroad industry.

Frankly, the Executive Committee had only two reasons for initiating this project. One was to make an earnest attempt to render a real service to the industry and the profession by clearing up what seemed to be a general misunderstanding as to the true situation in its field, and the other was curiosity as to what the conditions actually were.

The instructions from the Executive Committee to its Sub-Committee on Professional Service were quite clear in stating that the work was to be confined to the collection of facts and information only and to present them in as uncolored a manner as possible. In other words, it was to be considered as a report of an engineering investigation prepared by engineers which necessarily had to be sponsored by the Society. The Sub-Committee adhered strictly to this policy in the preparation of its progress report in 1926, and did the same in the preparation of its final report which was presented March 14, 1928. This final report, therefore, contained only what the Sub-Committee considered to be facts and reliable information. The remaining material, or what may be termed the by-products, was sorted and classified for the use of other committees of the A.S.M.E. and other societies that are working along lines closely allied to that of the Sub-Committee on Professional Service.

As to the ultimate value of the project, the Executive Committee of the Railroad Division has never expected and it does not now expect the two allied industries to be remade as the result of this effort. In the first place, its utility to the individual depends largely on his ability to analyze facts and data that have been collected for study. Although this quality is fundamental to the engineering profession, the average engineer seldom acquires it until several years after leaving college. This is to be regretted, for it is during the first few years of his productive life that the young mechanical engineer usually commits himself to a definite line of work. It therefore appears that its greatest usefulness will be to the mechanical-engineering faculties of the various technical schools and colleges.

Data and facts relative to the opportunities afforded the mechanical engineer in other industries should be available to the young mechanical engineer for purposes of comparison. The Executive Committee, Railroad Division, has from the beginning considered the work of its Sub-Committee on Professional Service to be only its part of a complete report to be made by all of the professional divisions of the Society showing the opportunities afforded the mechanical engineer in industry as a whole. Only when this work is accomplished will the project it has initiated be of real service. In fact, there is a possibility that many young mechanical engineers will be unduly influenced by the study of only one report and decide to enter railroad work when they should be starting in some other field of endeavor.

Quite a number of engineering schools and colleges have reported that they are not able to meet the demand for mechanical engineers made on them by various companies. The same situation is reported by the employment department of the Society. On the other hand, it is reported that the number of students actually enrolling in mechanical-engineering courses is decreasing instead of increasing. Although there are some who disagree, it is the opinion of the writer that this decrease is largely due to pessimistic propaganda relative to the outlook for the mechanical engineer in industry.

If we can take the facts and data that have been collected by the Railroad Division, Sub-Committee on Professional Service, as evidence of what the situation is with respect to the mechanical engineer in industry as a whole, it can be said that the actual conditions have been misrepresented. There are too many well-meaning mechanical engineers, as well as others outside the profession, who seem to believe that one or two swallows make a summer. In other words, they have jumped at conclusions that the mechanical-engineering profession is devoid of opportunity, underpaid, and what not, and base their conclusions on the experiences of themselves or other individuals. But does this picture the average career for everybody in the profession? What do we know about the situation in the other engineering professions, the legal or the medical profession? Very little.

Consider the railroad industry. There are in the files of the Railroad Division Sub-Committee on Professional Service, letters from a number of mechanical engineers to the effect that they very strongly advise students not to go into railroad work. The past experience of graduates of their acquaintance who have entered railroad work and eventually entered other lines of endeavor, has led them, they say, to adopt this attitude.

The writer would like to know how these members of the profession feel toward other industries. He would also like to know how many of these graduates left railroad work for positions with railroad-supply companies. Perhaps the critics do not realize the fact that in all probability the railroad-supply companies would not have employed these men without a certain amount of railroad experience.

But what of the effect of this pessimistic gossip or propaganda with respect to the prospects for mechanical engineers in the railroad industry when considered with industry as a whole? The Class I railroads are by far the largest employers of labor of any industry in the United States. The total number of wage earners they employ practically equals that of the iron and steel industry, the textile, the automobile, and the lumber industries combined. No wonder there is a decrease in the number of students enrolling in mechanical-engineering courses. Yet the historians and writers tell us that we are living in a mechanical age. It would seem that it is time for the profession to get the facts and proceed to combat this pessimistic propaganda by making the facts known.

Undoubtedly considerable of this gossip or pessimistic propaganda is due to the considerable number of mechanical engineers who are square pegs in round holes, or who think they are. It seems to be a trait of human nature to think that the other fellow has a better job than we have. It is here that the Executive Committee of the Railroad Division has hoped it would be able to lend some assistance to the individual himself. As was brought out in a preceding paragraph, it has never entertained the idea that its project would solve the problem. Human na-

[1] See Mechanical Engineering, vol. 49, no. 2, February, 1927, p. 147.

ture is too complex for such expectations. Unless a man has committed some crime, we cannot force him to do something he does not want to. We can, perhaps, persuade him to study and analyze facts and data which should be of considerable assistance to him in seeing that he does not become a misfit in industry. The selection of a life work is one of his most important problems. The stressing of the importance of this problem should be given a prominent place by the college professor.

The general scheme of the Sub-Committee on Professional Service is to prepare its final report so that it can be utilized by faculty advisers to mechanical-engineering students and others in the profession who are occasionally called on to advise the young mechanical engineer as to what line of work he should enter. It is the opinion of the writer that the burden of making the final decision should rest solely with the young engineer himself. In other words, give him the facts and then let him make his own mistakes.

It is the opinion of the writer that the facts and data pertaining to the status of the mechanical engineer collected by each professional division for its field can be coordinated with a student-rating system such as that in effect at Purdue University.[2] The writer, however, has made no study of this system nor has he made any serious attempt to see how the report of a professional division sub-committee on professional service could be used in conjunction with such a system. Such a study is outside of the work that has been assigned by the Executive Committee of the Railroad Division to its Sub-Committee on Professional Service.

Marion B. Richardson.[3]

Flood Protection for the Mississippi Valley

A Committee appointed by the American Engineering Council to consider the problems arising from the Mississippi River floods, and consisting of Messrs. Gardner S. Williams, Chairman, Baxter L. Brown, John R. Freeman, and Arthur E. Morgan, has recently reported its findings and recommendations substantially as given below.

Lack of Essential Data. The data now available are altogether insufficient to warrant the laying out of a permanent plan of flood protection for the Mississippi Valley and the cost of such protection as is now recommended may exceed that suggested by the Mississippi River Commission by at least as much as the estimates of that body exceed those of the Chief of Engineers.

Administration. The solution of the Mississippi River problem and the administration of the measures adopted for river control should be placed in the hands of a Mississippi River Conservancy Board to consist of five or seven members to be appointed by the President from among the most eminent hydraulic engineers whose services may be obtained; the members of the said Board to hold office for limited terms, to be appointed in rotation, each to receive necessary expenses and reasonable compensation for such portion of their time as may be necessary to conduct the work of the Board; they to have authority to appoint a Chief Engineer and provide for the appointment of such assistants as may be needed to carry on the work assigned to them.

Immediate Measures. Immediate steps should be taken to repair damage to present construction and do such further work as may be urgently necessary in the judgment of the above-named Board and which will not materially interfere with the possible development of future plans, the cost thereof to be borne by the national government.

Economic Survey. Before any general plan of flood protection and river improvement is adopted, and before the National Government commits itself to a policy of financial responsibility for flood control, a thorough economic survey should be made of the conditions, needs, and resources of the flood-affected regions, to furnish a basis for the distributions of cost and a decision of the nature and extent of the improvement justified.

Topographic Maps. The work of topographic mapping provided for in the Temple Act should be pushed as rapidly as possible throughout the Mississippi Basin, and if necessary to accomplishment of the complete mapping of the flood-affected area in the immediate future, more liberal terms should be offered the states in that area to secure their cooperation.

Hydraulic Laboratories. Any hydraulic or other laboratories to be established in connection with the solution of flood or other hydraulic problems, should be under the control and management of research scientists with conditions insuring continuity of effort through long periods of years, and not subject to the changes due to rotation in office or frequent modifications of policy.

Future Investigation. Every remote possibility for the control of the Mississippi should be examined until its feasibility has been determined or its consideration eliminated.

Responsibility of Up-River States. There is no evidence tending to place responsibility on the states whose waters are tributary to the Mississippi River system for adding to or affecting measurably the magnitudes or extent of floods beyond those naturally existent.

Reforestation. Reforestation as generally understood is not a practicable method of dealing with flood conditions on the Mississippi River, but the destruction or removal of vegetable cover in regions subject to erosion has increased the sediment carried by the streams draining them, and, therefore, the cultivation of vegetable cover, or other methods of erosion control in such regions, may be a factor worthy of consideration as incidental to the ultimate solution of the Mississippi flood problem.

Reservoirs in Remote Locations. Storage reservoirs on the remote head waters of tributary streams have too limited an effect upon the floods of the Mississippi River to justify their inclusion in the flood-protection program for that river.

Diversion Channels. The adoption of any specific plans for diversion channels should wait upon far more complete studies of the areas involved and of the probable effects of such diversions.

Constitutional Authority. In the opinion of the Committee, the authority of the general government to deal with such questions as are involved in the Mississippi River problem should no longer hang upon such slender threads as the general-welfare clause or the regulation-of-commerce clause of the Constitution, but the Constitution of these United States should be amended to confer upon the general government the authority to control and administer the national waters and to assess damages and allocate benefits and costs in connection therewith; and only by the procedure which such an amendment, followed by the passage of a Federal Water Control law, would make possible can an equitable or justifiable distribution or allocation of the costs of river improvement and flood protection be assured.

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[2] For a description of the rating system at Purdue University, see *Power*, June 21, 1927, p. 956.

[3] Associate Editor, *Railway Mechanical Engineer*, New York. Chairman, Sub-Committee on Professional Service, A.S.M.E. Railroad Division.

Third Midwest Power Conference

Papers on Relation of Power Development to Flood Control and on Power-Station Economics

THE Third Midwest Power Conference was held at the Hotel Stevens, Chicago, Ill., February 14 to 17. It was sponsored by the local sections, regional and professional divisions of the American Institute of Electrical Engineers, The American Society of Mechanical Engineers, the American Institute of Mining Engineers, the National Electric Light Association, the Western Society of Engineers, the National Safety Council, the American Society of Civil Engineers, the American Society of Refrigerating Engineers, and the American Society of Heating and Ventilating Engineers.

The Conference has been developed to consider in what ways the available power resources of the country may best be developed for the benefit of society and the industries.

The principal feature of the first session of the Conference on Tuesday morning was an address by Glenn Frank, President of the University of Wisconsin, on "Power, the Background of Today's Civilization," which will be found elsewhere in this issue. This was followed by a paper by Major Rufus W. Putnam, President of the Conference, entitled "The Power Situation in the Heart of the Middle West," which contained much statistical information about the extent of the distribution of power in the Great Lakes region and viewed the future of the power situation in the Middle West with optimism.

What the use of electrical power has meant to the average American citizen was brought out in three papers: "America's Part in the Romance of Power," by W. A. Durgin, Director of Public Relations, Commonwealth Edison Co., who contrasted the conditions of labor and daily life in this country and in Europe and other parts of the world; "Drudgery Banished from the Home," by Mrs. J. D. Sherman, President, General Federation of Women's Clubs, Washington, D. C.; and "How to Make the Burden Bearer Bear the Burden," by Burke Corcoran, Secretary, Electrical Association of Chicago.

The two sessions on Wednesday were devoted to the general subject of the relation of power development to flood control and other river problems. The paper on "The General Flood-Control Problems of the Mississippi System," by General Edgar Jadwin, Chief of Engineers, United States Army, was read in his absence by Col. E. A. Schulz. The following conclusions were drawn by D. W. Mead, Madison, Wis., in his paper, "Problems of Storage for Flood Control and for Power Development:"

1 That approximately complete control of a river system such as is provided by the Great Lakes is a definite advantage to both flood prevention and water-power development, but that such control is practically impossible by artificial means on any large river system.

2 That with partial control on any large river system the combined uses of the reservoir for flood protection and other purposes are so antagonistic as to be inexpedient.

3 That reservoirs for whatever purpose they may be constructed will have minor favorable effects for most other purposes in that they will tend to equalize the stream flow.

4 That in general reservoirs should be built and operated for a single purpose when found financially advantageous for such a purpose, and that with few exceptions the use of reservoirs for combined services is not warranted except when they can be so used as not to interfere with the purpose for which they were constructed.

In a paper on the "Boulder Dam Project on the Colorado River," Col. William Kelly, of Buffalo, N. Y., drew the following conclusions:

Adequate flood protection can be given the lower basin of the Colorado River by channel work through the delta and a flood reservoir in Mohave Valley at a cost of from $15,000,000 to $25,000,000.

Not only is there no physical or economical advantage in combining flood protection with either the All-American Canal project, the Boulder Canyon power project, or the Los Angeles municipal water-supply project, but if the flood project had not been saddled with such projects it is quite probable that it might have been an accomplished fact before this.

The separate flood project can be built at once without injustice to the other states in the Colorado basin and without giving water to Mexico. The Boulder Dam project cannot.

If the separate flood project be adopted, flood protection can be had in from three to four years, whereas if combined with Boulder Dam it cannot be had in less than seven and perhaps twelve years.

Speaking on "The Status of Hydroelectric Development from the Point of View of the Federal Power Commission," Major G. E. Edgerton, Chief Engineer, Federal Power Commission, Washington, D. C., closed as follows:

"On the whole, the present status of hydroelectric development is, perhaps, satisfactory; it can scarcely be described as gratifying. The present and prospective rates of development compare not unfavorably with those of steam power, but only a small part of the potential water-power resources of the country has actually been put to use. Political considerations still prevent the application of the principles of the Federal water-power act to some of our major water powers, and the states do not all exert their extensive authority in the field of water power wisely and effectively. It is the aim of the Federal Power Commission to further the development of water power as extensively as economic conditions will permit. That objective can be attained only if the states adopt a similar policy and if the existing restrictions upon important power streams are permanently removed."

The scope of the survey and the experience of the U. S. District Engineer Office at Chattanooga in its conduct of the survey was covered by Major Lewis H. Watson, Corps of Engineers, U. S. Army, in his paper on "The Survey of the Tennessee River and Its Tributaries."

"Progress and Trend in Hydraulic Power Development," was the title of a paper read by H. A. Hageman, Chief Hydraulic Engineer, Stone and Webster, Inc., Boston, Mass. It is hoped that this paper will appear in a later issue of MECHANICAL ENGINEERING and that the one by E. A. Forward, consulting engineer, Montreal, Canada, on "Navigation and Power Development on the St. Lawrence River," in which the Canadian point of view is ably set forth, will also be published in full.

The address at the Annual Banquet on Wednesday night was by Rufus C. Dawes, of Chicago, on "International Finance."

The economics of power stations was the main topic of the Thursday and Friday sessions. Alex Dow, President of the A.S.M.E., spoke on "Capital Costs with Relation to Economy of Central Stations." Following this, George A. Orrok, consulting engineer, New York, read a paper on "Operating Experiences with High-Pressure and High-Temperature Steam," which he closed with the following conclusions:

1 There appear to be no serious difficulties in the operation of plants using pressures ranging up to at least 2000 lb. per sq. in.

2 Four years' experience in continuous operation of super-

heaters raising the steam temperature to 850 deg. fahr. with ordinary steel superheater tubes has proved such operation commercial as no serious difficulties have been encountered.

3 Alloys steels for tubes, shells, and castings are available for more difficult operating conditions than have been heretofore tried out in practice. Boiler companies state that they are ready to guarantee service to 900 deg. fahr.

4 Operators report both thermal and commercial economy in the use of higher pressures, and this is evidenced by repeat orders for similar apparatus.

5 Commerical results have not been reported quantitatively, and we are no nearer an answer as to the most economical pressure and temperature to use for any given case.

"Trend and Development in Steam Generation" was the title of a paper by Thomas F. Murray of T. E. Murray, Inc., New York, read in Mr. Murray's absence by John A. Lawrence, vice-president of the company. The paper reviewed the steps which have been followed in the past few years in the development of boilers and furnaces with the introduction of the first stokers and later with the use of other types of fuels, and the effects which were produced on boiler and furnace design by high rates of operation.

Both Mr. Orrok's and Mr. Murray's papers drew considerable discussion from the floor.

The Friday morning session contained two papers on combustion control, one by T. A. Peebles, Hagan Corporation, Pittsburgh, Pa., on "Combustion Control in Industrial Plants," and the other by J. F. Shadgen, Smoot Engineering Co., New York, on "Boiler-Room Organization and Combustion Control."

Mr. Peebles gave the principal advantages of combustion control as proper division of the load among the boilers in service, adjustment of combustion rate in accordance with load, and proportioning of fuel to air supply. He then described a simple and effective way of accomplishing such results.

After presenting his analysis of the problem of boiler-room organization and combustion control, Mr. Shadgen said:

"It appears that a perfect organization scheme for boiler-room operation can be built around a comprehensive 'machine' combustion-control system, and that all elements are available and adaptable to any local problem. Any control system is to be used as a tool to the combustion engineer of the plant and allows that man, together with his operating crew and test gang, to maintain optimum efficiency over monthly and yearly periods independently of load fluctuations and in the coal supply.

"The management of a boiler room will be composed of a combustion specialist as general responsible supervisor, using the instruments as inspectors and performance checkers, the test engineers as tool setters, and the operators to keep a set of regulators and equipment in harmonious coordination. Each part has its definite function, as in a well-managed machine shop with automatic tools. To aim at complete automatic control is erroneous because no managing head can be replaced by a machine no matter how perfect or ingenious."

There was considerable discussion of these combustion-control papers. They were followed by one on "The Effect of Steam Reheating, Stage Feedwater Heating, and Boiler Reheating on Steam-Turbine Practice and Development," by Edward Brown, Allis-Chalmers Co., Milwaukee, Wis.; and another, by Dr. S. W. Parr and F. C. Straub, on "Embrittlement of Boiler Plate." It is the intention to publish the paper on embrittlement at an early date.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Books Received in the Library

Die Abwärmetechnik, Vol. 1; Grundlagen. By Hans Balcke. München and Berlin, R. Oldenbourg, 1928. Cloth, 6 × 9 in., 290 pp., illus., diagrams, tables, 15 r.m.

The first volume of a three-volume work upon waste-heat engineering. It discusses first the sources of waste heat, including exhaust steam, flue gases, condensed steam, cooling water, and excess electrical energy. It then takes up the principal elements of plants for utilizing waste heat and considers in detail the construction, use, and efficiency of each.

Construction Job Management. By Charles F. Dingman. McGraw-Hill Book Co., New York, 1928. Fabrikoid, 4 × 7 in., 220 pp., illus., diagrams, tables, $2.50.

Aims to place before the builder, particularly the inexperienced builder, a knowledge of the most effective ways of handling the several branches of building construction and of coordinating the work of the various trades employed. The chapters deal successively with the preparatory work, equipment, directing the work, organizing, handling masonry work, fireproof construction, plastering, and carpentry, and relations with subcontractors. Much practical advice is condensed into small space.

Diesel Engines for Land and Marine Work. By A. P. Chalkley. Sixth edition. D. Van Nostrand Co., New York, 1927. Cloth. 6 × 9 in., 320 pp., illus., diagrams, $8.

This book aims to give a comprehensive outline of the present position of the Diesel engine and its applications, particularly its application to marine work. The new edition reflects the advances since the last edition. Descriptions and illustrations of many new engines have been added, together with new matter upon modern development in general design. Diesel's original English patent is printed as an appendix.

Dieselmaschinen; Grundlagen, Bauarten, Probleme. By Julius Magg. V.D.I. Verlag, Berlin, 1928. Cloth, 9 × 12 in., 278 pp., illus., plates, diagrams, portrait, 26 r.m.

The aim of this book is to provide a general survey of our knowledge of the theory and construction of the Diesel engine, and of the trend of future development, which will be as concise as possible and yet be reasonably full and comprehensive in scope.

The first section presents the fundamental principles of the engine, treating of its thermodynamics and thermometry, the calculation of the principal dimensions, its fuels, and its economy and power. The second section discusses design. It describes and illustrates the various types, presenting numerous models that have not been published previously. Chapters are devoted to locomotives, automobiles, and ship propulsion. In the third section the author discusses unsettled and unsolved problems in design, using the unpublished results of his own experimental work. A new theory of scavenging in two-cycle engines is presented, and its practical uses shown. The use of exhaust-gas turbines is examined critically.

Electric Control Gear and Industrial Electrification. By William Wilson. Oxford University Press, American Branch, New York, 1927. Cloth, 6 × 9 in., 361 pp., illus., tables, $8.50.

A comprehensive treatment of electrical control gear as used in industry. The author first discusses the design, arrangement, and construction of controlling apparatus, considering first the individual items, and then their association and combination to form complete schemes with any desired characteristics. Typical installations in the principal departments of industrial work, such as steel mills, hoisting, cranes, machine tools, and textile and printing plants, are then described.

Elements of Machine Design, Part 1. By W. Cawthorne Unwin and A. L. Mellanby. New edition. Longmans, Green & Co., New York, 1927. (Textbooks of Science.) Cloth, 6 × 9 in., 531 pp., illus., diagrams, tables, $5.

Unwin's Machine Design is so widely known that no comment upon its plan and scope is necessary. Since its first appearance, fifty years ago, it has remained a favorite text on its subject. The new edition shows no great change in scope and arrangement over the preceding one, but Professor Mellanby has altered and rewritten such parts of the text as no longer represented modern practice, and has added new matter when it was necessary.

Engineering of Power Plants. By Robert H. Fernald and George A. Orrok. Third edition. McGraw-Hill Book Co., New York, 1927. Cloth, 6 × 9 in., 663 pp., illus., diagrams, tables, $5.50.

This work, intended primarily as a textbook for students of all branches of engineering, is an epitome of modern practice. The authors emphasize the fact that engineering is an art, not an exact science, and also stress the commercial aspects of the subject. Steam, gas, compressed air, and water power are discussed. The new edition incorporates the developments in the production of power during the last five years.

Die Güterwagen der Deutschen Reichsbahn. Herausgegeben im Auftrage des Reichsbahnzentralamtes in Berlin. Third edition. V.D.I. Verlag, Berlin, 1928. Paper, 6 × 8 in., 30 pp., illus., 1 r.m.

A pamphlet prepared for shippers of freight in Germany. The kinds of freight cars in use are described, their capacities and dimensions given, and the kinds of freight for which they may be used are stated. Directions for ordering cars are given, and the capacities of cars in neighboring countries are supplied.

Hamilton Aerial Map of Manhattan. Hamilton Aerial Maps, New York, 1927. Size of sheet 32 × 34. Complete with binder, $55.00, plus service feature to atlas owners, $1.00 per duplicate sheet. (For small area of the island only, a pocket edition is published of one sheet for $3.00.)

This aerial map will cover Manhattan Island on a scale of 200 ft. to the inch. Fourteen sheets have been published, extending from the Battery to Fifty-ninth Street, and the remaining seventeen are being prepared. The map is printed from aerial photographs by a process which gives very clear reproductions. Street names have been inserted and a street index is provided. Street numbers are also indicated. The publication is available complete in a loose-leaf binder, or single sheets may be had in pocket cases.

Handbuch des Beratenden Ingenieurs. By S. Herzog. Ferdinand Enke, Stuttgart, 1925. Paper, 7 × 10 in., 519 pp., 20 mk.; bound, 22.50 mk.

A treatise upon the work of the consulting engineer, particularly one engaged in the investigation of manufacturing and industrial enterprises. Apparently the first attempt to present in systematic fashion the general principles upon which such investigations should be based. After an introductory account of the evolution of the consulting engineer, his duties are discussed. Sketches and plans are then discussed, after which the various duties of the consultant—technical, statistical, commercial and financial—are treated, both with reference to existing industries and new projects. Numerous examples of the practical application of the methods are included.

Handbuch für Lehrlinge der Allgemeinen Feinmechanik. By Robert Bosch. Third edition. V.D.I. Verlag, Berlin, 1927. 2 vols. in one. Cloth, 9 × 12 in., illus., diagrams, 15 r.m.

A handbook on lathe work and the use of hand tools, for use by apprentices and in manual-training courses. The text is clear and concise, and is illustrated by an unusually well-planned collection of drawings which show both correct and incorrect methods.

Heating and Ventilation. By C. W. Brabbée. McGraw-Hill Book Co., New York, 1927. Cloth, 6 × 9 in., 332 pp., illus., diagrams, charts, tables, $4.50.

This volume makes accessible to American engineers the results of the experimental work, extending over many years, undertaken by Dr. Rietschel and Dr. Brabbée in the Research Laboratory of Heating and Ventilation at the University of Berlin. It is a translation of the seventh edition of Heizungs- und Lueftungstechnik, adapted to American conditions by the abridgment of certain parts and the addition or emphasis of material suited to our needs. The book is intended to assist in the practical design of heating and ventilating systems. Theory is given only briefly; charts and tables which facilitate rapid computation and design are numerous.

In a Persian Oil Field. By J. W. Williamson. Ernest Benn, Ltd., London, 1927. Cloth, 6 × 9 in., 189 pp., illus., 7s., 6d.

Most contributions to the subject of the applications of science to industry approach the subject on general lines and work down to particular instances. Mr. Williamson adopts the reverse of this process. He has taken one corporation, the Anglo-Persian Oil Co., and studied the ways in which it has applied scientific knowledge and scientific methods to its problems. He also describes the industrial, educational, and social developments that have been undertaken. The book is an interesting account for general readers of the methods of dealing with the raw material and also with the human and sociological factors involved in large-scale production.

Introduction Générale a la Photométrie. By Charles Fabry. Revue d'Optique théorique et instrumentale, Paris, 1927. (Encyclopédie Photométrique, vol. 1.) Paper, 6 × 9 in., 178 pp., diagrams, tables, 20 francs.

The *Revue d'Optique* has undertaken the publication of a photometric encyclopedia composed of some twenty-seven volumes, each of which will deal with a definite aspect of the broad subject of the measurement of the intensity of visible or invisible radiation.

The present volume, by the Director of the Institute of Theoretical and Applied Optics, presents the fundamental ideas, the definitions, and the units used in measuring radiant energy, and forms a general introduction to the volumes which are to follow.

Introduction to the Metallurgy of Iron and Steel. By H. M. Boylston. John Wiley & Sons, New York, 1928. Cloth, 6 × 9 in., 571 pp., illus., tables, $5.

A well-illustrated, well-written textbook upon the manufacture of iron and steel, as now carried on in America, which covers the entire industry without attempting to be exhaustive. Professor Boylston gives particular attention to the winning of the metal from its ores and the processes for refining it to the desired quality, and gives less space to processes of shaping steel and to metallography and heat treatment. The book is intended as a college textbook, but is also suitable for those with only a general interest in the subject.

Jahrbuch 1927, der Deutschen Versuchsanstalt für Luftfahrt. E. V., Berlin-Adlershof. R. Oldenbourg, Münich and Berlin, 1927. Cloth, 9 × 12 in., 151 pp., illus., diagrams, tables, 13 r.m.

This volume contains the official report of the Versuchsanstalt for the year 1926–7, and 21 reports on investigations carried out under its auspices. These included tests of materials used in aircraft, methods of construction, studies of theoretical questions, etc.

Journal of the Royal Technical College, Glasgow. No. 4, December, 1927. Glasgow Royal Technical College, 1927. Paper, 7 × 10 in., 128 pp., illus., diagrams, tables, 10s. 6d.

This paper-bound book brings together thirteen papers upon researches carried on at the College. The researches are in the fields of electrical engineering, civil engineering, chemistry, metallurgy, and mechanical engineering.

Kokerei- und Gaswerksöfen. By L. Litinsky. (Kohle, Koks, Teer, vol. 17.) Wilhelm Knapp, Halle (Saale), 1928. Paper, 6 × 9 in., 336 pp., illus., diagrams, tables, 22.80 r.m.

This monograph treats exhaustively of coke ovens, and retorts and furnaces for generating fuel gas. The construction, output, heat economy, structural materials, etc., of these furnaces are discussed from an engineering point of view by an engineer who has specialized in this field and who here endeavors to discuss all questions that arise concerning furnaces for the distillation of coal. The volume forms part of an extensive series upon the mining and utilization of fuel.

Permanent-Way Material, Plate-Laying, and Points and Crossings. By W. H. Cole. Ninth edition, revised by Gordon Hearn. E. & F. N. Spon, London, 1928. Cloth, 5 × 7 in., 245 pp., diagrams, tables, 12s. 6d.

A standard English book on railroad track and trackwork, treating of track standards, rails and accessories, track construction, track maintenance, switches and crossings, and signaling and interlocking. This edition covers both English and American practice, it is stated, and gives the standard types of switches and crossings recently designed in England.

Pyroxylin Enamels and Lacquers. By Samuel P. Wilson. Second edition. D. Van Nostrand Co., New York, 1927. Cloth, 6 × 9 in., 253 pp., $3.50.

A practical book on the manufacture and use of these lacquers, written by a manufacturer. The properties of the raw materials are set forth, formulas are given for lacquers for various purposes, and the machinery used for mixing and applying is described. Methods of spraying and brushing are explained.

Radio Engineering Principles. By Henri Lauer and Harry L. Brown. Second edition. McGraw-Hill Book Co., New York, 1928. Cloth, 6 × 9 in., 301 pp., diagrams, $3.50.

The object of the authors has been to discuss thoroughly the principles of radio from the engineering point of view, and to give the general means of utilizing them, so that they may be applied to any specific apparatus. Most of the book is devoted to a study of the characteristics and use of the three-electrode vacuum tube. The new edition follows the plan of the preceding one, but has been revised and extended to cover later developments.

Rayon Industry. By Mois H. Avram. D. Van Nostrand Co., New York, 1927. Cloth, 6 × 9 in., 622 pp., illus., tables, $10.

A comprehensive account of the origin, growth, and present condition of the rayon industry, which considers both the technical and commercial aspects of the subject. The various processes are described, together with the raw materials. Information is given on production, products, testing, and processing. The important patents and the producers of rayon are tabulated. A good bibliography is included.

Riveted Joints for Pressure Vessels. By George B. Haven and George W. Swett. John Wiley & Sons, New York, 1927. Cloth, 6 × 9 in., 119 pp., diagrams, tables, $1.75.

This small volume is devoted to the most important single feature in the design of pressure apparatus, the rivet joint. The subject is discussed in detail, with consideration of the various circumstances that affect the arrangement and size of rivets. The book is almost entirely an excerpt from The Design of Steam Boilers and Pressure Vessels, by the same authors.

Rivure et Soudure des Chaudieres a Vapeur. By E. Hoehn. Ch. Beranger, Paris et Liège. Paper, 6 × 9 in., 155 pp., diagrams, tables.

A valuable report upon the investigations of welded and riveted boilers which have for some years been carried on by the Swiss steam-boiler-owners' association. The conditions under which thick plates may be riveted were carefully investigated, the tests being carried out with a new method of determining the state of tension in riveted vessels.

Spur Gears. By Earle Buckingham. McGraw-Hill Book Co., New York, 1928. Cloth, 6 × 9 in., 451 pp., illus., diagrams, tables, $5.

With the introduction of the formed cutter for producing gear teeth, there were introduced into gear-tooth design certain conventions based upon the limitations of such formed tools. Many of these conventions were carried over into the design of gear-tooth forms produced by molding or generating processes, although the limitations of these processes are very different, and adherence to these conventions sometimes results in partial loss of the benefits of improved materials and methods.

In this book the author attempts to bring out the fundamental characteristics of spur gears, in the hope that more effective use may be made of the facilities now available for producing them. The design, operation and production of involute spur-gear teeth is discussed, with a complete mathematical exposition of the subject.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following pages appear in the current sections of A.S.M.E. Transactions as published in its new form. These sections have been sent to all who registered in the Applied Mechanics, Oil and Gas Power, and Hydraulic Divisions. Other sections are in the course of preparation and will be announced, when completed, in later issues of Mechanical Engineering.

APPLIED MECHANICS SECTION

Analysis of Strains and Stresses in a Wristpin of an Automobile Engine by the Mathematical Theory of Elasticity

By GUY B. COLLIER

Consulting and Designing Engineer, New York, N. Y.

THE paper presents a mathematical analysis of strains and stresses in a wristpin, showing that wristpins can be made considerably lighter than in present-day practice and still have requisite strength, this being obtained by making certain parts of lesser and others of greater thickness than is now done. This is illustrated by numerical data and (in exaggerated form) by drawings showing how, among other things, inertia losses and motor vibrations can also be reduced.

The author regards the wristpin as a beam fixed at each end and having a fixed load uniformly distributed over its length. The fixing of the load to the pin is effected by means of the bushing and its enclosing sleeve, at the upper end of the connecting rod. The stresses and strains imposed on such a structure are then considered. The system of simultaneous partial differential equations for an elastic cylinder subject to a bending-moment loading are integrated on the basis of knowing the form of the axial stress intensity. Complete expressions are next obtained for the three orthogonal strain displacements and thence for the radial and tangential stresses at any point of the metallic member; these last two combined with the axial stress give the resultant intensity at points in question. The solution involves certain constants of integration which make it more general in character than the conditions involved in the wristpin application, and the analysis can readily be extended. A numerical illustration of the method is given for a wristpin $1^1/_8$ in. in outside diameter and $^3/_{32}$ in. in radial thickness under certain conditions of service and loading for a motor of 6 in. stroke and $3^3/_4$ in. bore working under stated conditions of pressure, etc. The present calculations show that the parts of the wristpin within the connecting-rod sleeve and the piston bosses can be made of lesser thickness than has previously been considered necessary, while the part of pin in the gap between sleeve and boss should be reinforced or made thicker.

An Investigation of the Performance of Waste-Packed Armature Bearings

By G. B. KARELITZ

Research Department, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

SOME of the observations made while experimenting with full-size armature bearings are recorded in this paper. The importance of taking care in the packing of bearings is brought forth. The advantages of a constant oil lift are pointed out, while the effect of grooving is discussed. Bearing-shell temperatures for varying loads and speeds are given. The data collected may be of interest to designers as well as to engineers in charge of maintenance of railway motors.

Measurement of Flow of Air and Gas

By SANFORD A. MOSS

Thomson Research Laboratory, General Electric Co., Lynn, Mass.

FLOW of air or other gas is very commonly obtained by use of so-called measuring nozzles, which may be nozzles with well-rounded or streamline approach, venturi meters, or orifices in a thin plate.

Much experience with such apparatus has been accumulated at the Lynn Works of the General Electric Company by the engineers, past and present, of the centrifugal-compressor department and the Thomson Research Laboratory. This has shown that some items in common use are well-founded, while others are without good foundation, and has resulted in the development of some new items. The present paper gives a brief résumé of all of the items of a satisfactory set-up for laboratory flow measurement, based on this experience.

Special attention is given to points of novelty, including a selection of the fundamental constants for air, and a complete set of practical formulas for computation of the flow from test observations, for air and other practically perfect gases. It is of course to be understood that there are ways of handling the various items other than those given by the author, which may be equally correct. The paper is not an exposition of all flow-measuring methods, but merely gives one good way of handling each item, regardless of the existence of other ways perhaps equally good.

The Effect of Entrance and Discharge Angles on the Performance of a Centrifugal Fan

By GEORGES SAMUEL WILSON, WILLIAM LYLE DUDLEY, AND HARRY JOHN McINTYRE

Respectively Professor of Mechanical Engineering, University of Washington, Vice-President and Chief Engineer, Western Blower Co., and Assistant Professor of Mechanical Engineering, University of Washington, Seattle, Wash.

IN THIS paper the authors discuss tests conducted by them to determine the variations in the operating characteristics of a backward-curved-blade fan as affected by (*a*) blade entrance angles, (*b*) blade discharge angles, and (*c*) fixed entrance and discharge angles but with different wheel diameters. A brief discussion of static pressure in a centrifugal fan, with the development of equations, opens the paper. Then follows a description of the test unit and the method of conducting the tests. A discussion of observed results, in which several sets of curves are introduced, forms the body of the paper. The authors reach the conclusion that loss by shock at entrance is influenced by the entrance angle. With constant entrance blade angles

and diameter of wheel, the pressure and capacity are increased with increase in the value of the blade discharge angle. The shape of the passageway through the wheel is recognized as a factor in fan losses. Increasing diameter of symmetrical wheels, used in the same housing and operated at constant tip speed was found to increase the pressure-capacity characteristics and greatly improve the efficiency.

Progress in Lubrication Research

THIS report, contributed by the A.S.M.E. Special Committee on Lubrication, summarizes its activities during the five years since its previous or third report was submitted. The present report deals with the viscosity of lubricants under high hydrostatic pressure, one of its appendixes dealing at length with experimental work carried on by R. V. Kleinschmidt at Harvard University; the oiliness of lubricating oils; the lubrication of journal bearings; and car-wheel friction losses. A second appendix consists of a brief bibliography containing a number of references which may be considered representative of contemporary lubrication research.

OIL AND GAS POWER SECTION

The Study of Oil Sprays for Fuel-Injection Engines by Means of High-Speed Motion Pictures

By EDWARD G. BEARDSLEY

Junior Mechanical Engineer, National Advisory Committee for Aeronautics, Langley Field, Hampton, Va.

APPARATUS for recording photographically the start, growth, and cut-off of oil sprays from injection valves has been developed at the Laboratory of the National Advisory Committee for Aeronautics at Langley Field, Va. The apparatus consists of a high-tension transformer by means of which a bank of condensers is charged to a high voltage. The controlled discharge of these condensers in sequence, at a rate of several thousand per second, produces electric sparks of sufficient intensity to illuminate the moving spray for photographing it. The sprays are injected from various types of valves into a chamber containing gases at pressures up to 600 lb. per sq. in. Several series of pictures are shown. The results give the effects of injection pressure, chamber pressure, specific gravity of the fuel oil used, and injection-valve design upon spray characteristics.

Efficiencies of Otto and Diesel Engines

By F. O. ELLENWOOD, F. C. EVANS, and C. T. CHWANG

Respectively Professor of Heat-Power Engineering, Cornell University, Ithaca, N. Y., former Assistant Professor of Heat-Power Engineering, Cornell University, Newport, Del., and former graduate student of Heat-Power Engineering, Cornell University, Washington, D. C.

THIS paper gives primarily the results of calculations for the ideal Otto and Diesel engines in which the working substance is a mixture of real gases. The results are presented in the form of convenient tables and curves that may be readily used by any engineer in the determination of the engine efficiencies of internal-combustion motors operating under the various conditions existing today. The general method of procedure is fully explained and the necessary equations are given.

The paper also considers the factors involved in the establishment of "real-mixture standards" on which to base the performance of Otto and Diesel engines, and compares the results obtained by somewhat different conceptions. The use of higher and lower heating values of the fuel in the various calculations involved is discussed, and the tables and curves for the 65 cases considered give the results for both values.

The importance of using engine efficiencies to express performance is stressed, and five illustrative examples indicate that some of the best internal-combustion motors have already been so well designed and built that they give the excellent result of engine efficiencies as high as 76 per cent.

Diesel Engines for Locomotives

By R. HILDEBRAND

Chief Engineer, Diesel Department, Fulton Iron Works Co., St. Louis, Mo.

OBJECTIONS to the steam locomotive are made on grounds of inefficiency, the author stating that 92 to 98 per cent of the heat in the coal is being wasted, while a Diesel locomotive has an efficiency of about 33 per cent. The Diesel locomotive, however, cannot be started under full load, cannot carry any overload without excessive pressure and temperatures, and is so inflexible that an indirect drive or transmission is necessary. The principal objections to the indirect drive are cited by the author, who then makes the proposal of improving the cylinders of the steam locomotive so that they may be used either as steam or Diesel cylinders or as both simultaneously, thus retaining the advantages of both types of engine. An explanation of the working of such an engine is given, and the conditions under which the various combinations of operation are to be used are explained. Typical indicator cards for steam, for Diesel, and for combination operation are given, and the advantages of the system are explained. In closing the author answers a number of questions and objections which naturally present themselves.

Oil-Spray Investigations of the N.A.C.A.

By W. F. JOACHIM

Mechanical Engineer, Langley Field, Hampton, Va.

THIS paper deals at length with oil-engine performance, combustion losses, and stresses the value of research. The oil-spray investigations of the National Advisory Committee for Aeronautics are gone into in some detail, and the author presents a number of photographic records of fuel sprays and graphs for use in studying spray characteristics and fuel injection in high-speed engines.

Experimental Combustion Chambers Designed for High-Speed Diesel Engines

By CARLTON KEMPER

Junior Mechanical Engineer, National Advisory Committee for Aeronautics, Langley Field, Hampton, Va.

IN THIS paper the preliminary requirement of the high-speed fuel-injection-engine problem is given, and analyses of the cycles used in this type of engine are included. There is also given a discussion of the effect of increasing speeds on the output of engines employing these cycles. The requirements of combustion chambers are set forth and results of experiments using three different types are given. The engine and testing apparatus are fully described and illustrated, and curves showing the performance of the engine when equipped with each of the special types of chambers are also shown.

Progress in Oil- and Gas-Power Engineering

THIS report, contributed by the A.S.M.E. Oil and Gas Power Division and first published in Mechanical Engineering for January, deals with Diesel locomotives, automotive Diesel engines, giant Diesels, Diesels for peak power, continuous production, accessories, trend of design, research, activities and needs of the industry, and the future outlook. A bibliography is appended which covers the most important contributions of the years 1926 and 1927 bearing on the subjects dealt with in the report.

HYDRAULIC SECTION

Centrifugal Pumps

By H. T. Davey

Bexley Heath, Kent, England

IN THIS paper the author first discusses general considerations regarding losses, disk friction, specific speed, etc. He then sets forth at length the principles governing design of the volute, suction and delivery pipes, impeller, bearings and glands, priming apparatus, valves, etc. He closes by briefly considering materials used in the construction of pumps for various purposes.

A Method of Analyzing the Performance Curves of Centrifugal Pumps

By Joseph Lichtenstein

Bethlehem Shipbuilding Corporation, Elizabeth, N. J.

THE discrepancy between the theoretical results of the classical one-dimensional theory used in calculating centrifugal pumps and actual practice makes it necessary to introduce correction factors which can only be deduced from tests. The designer of centrifugal pumps has to his disposition an abundant amount of ordinary performance curves. This paper presents a graphical as well as an analytical method of determining from these test curves all the correction factors necessary to bring in accordance theory and practice. At the same time, these correction factors are introduced into the equations of the classical one-dimensional theory, and new equations are thus developed which can be used for calculating new pumps on the supposition that these correction factors are known.

A New Method of Separating the Hydraulic Losses in a Centrifugal Pump

By Michael D. Aisenstein

Hydraulic Engineer, Byron D. Jackson Pump Mfg. Co., Berkeley, Calif.

THE so-called hydraulic losses in a centrifugal pump are composed of friction losses and shock loss. The friction losses are those which are due to resistance offered to the water by the walls of the runner and case. The shock loss may be considered as due to the sudden enlargement of passages.

It is important for the designer to know how the losses are distributed and to have a method of separating them, so that by studying the variation of these losses he may decide in which direction improvement should progress.

The purpose of this paper is to present a method by means of which these losses may be determined separately from the head-capacity curve of a given centrifugal pump. An illustrative example of the equations developed by the author is included.

Progress in Hydraulics

THIS report, contributed by the A.S.M.E. Hydraulic Division and first published in Mechanical Engineering for January deals with the economic and political aspects of electric-utility operation, improvements in hydro-power machinery and plant construction, the broader possibilities of economic hydroelectric plant construction, and research in the field of hydraulics.

NOTE: Those who have not registered in either the Applied Mechanics, Oil and Gas Power, or Hydraulic Divisions of the A.S.M.E., and who desire copies of any of the papers abstracted on this and preceding pages, may obtain them by using the form given below:

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